COMBUSTION

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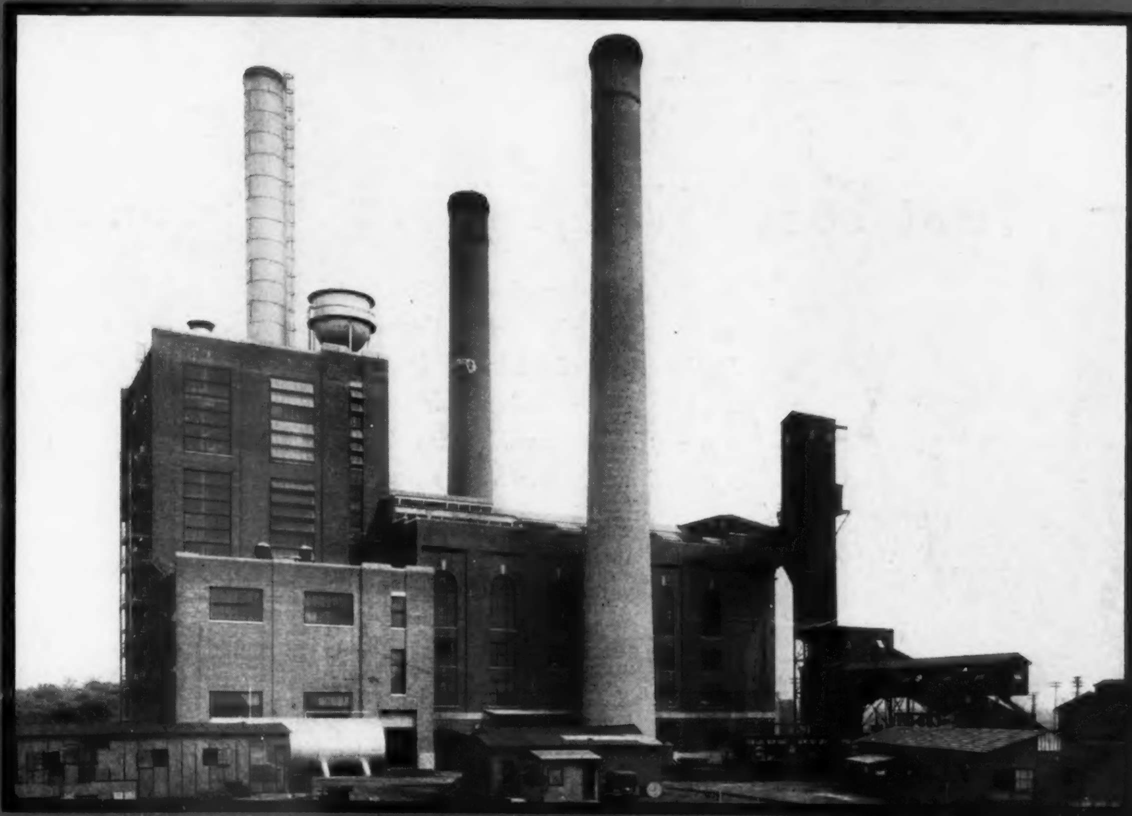

Burlington Generating Station, Public Service Electric and Gas Company of New Jersey

LARGE ANTHRACITE MINE
INSTALLS CENTRAL STEAM PLANT

MODERN TRENDS IN THE USE OF
WOOD WASTE FOR FUEL

COMBUSTION

VOLUME FOUR • NUMBER NINE

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EDITORIALS

DEPARTMENTS

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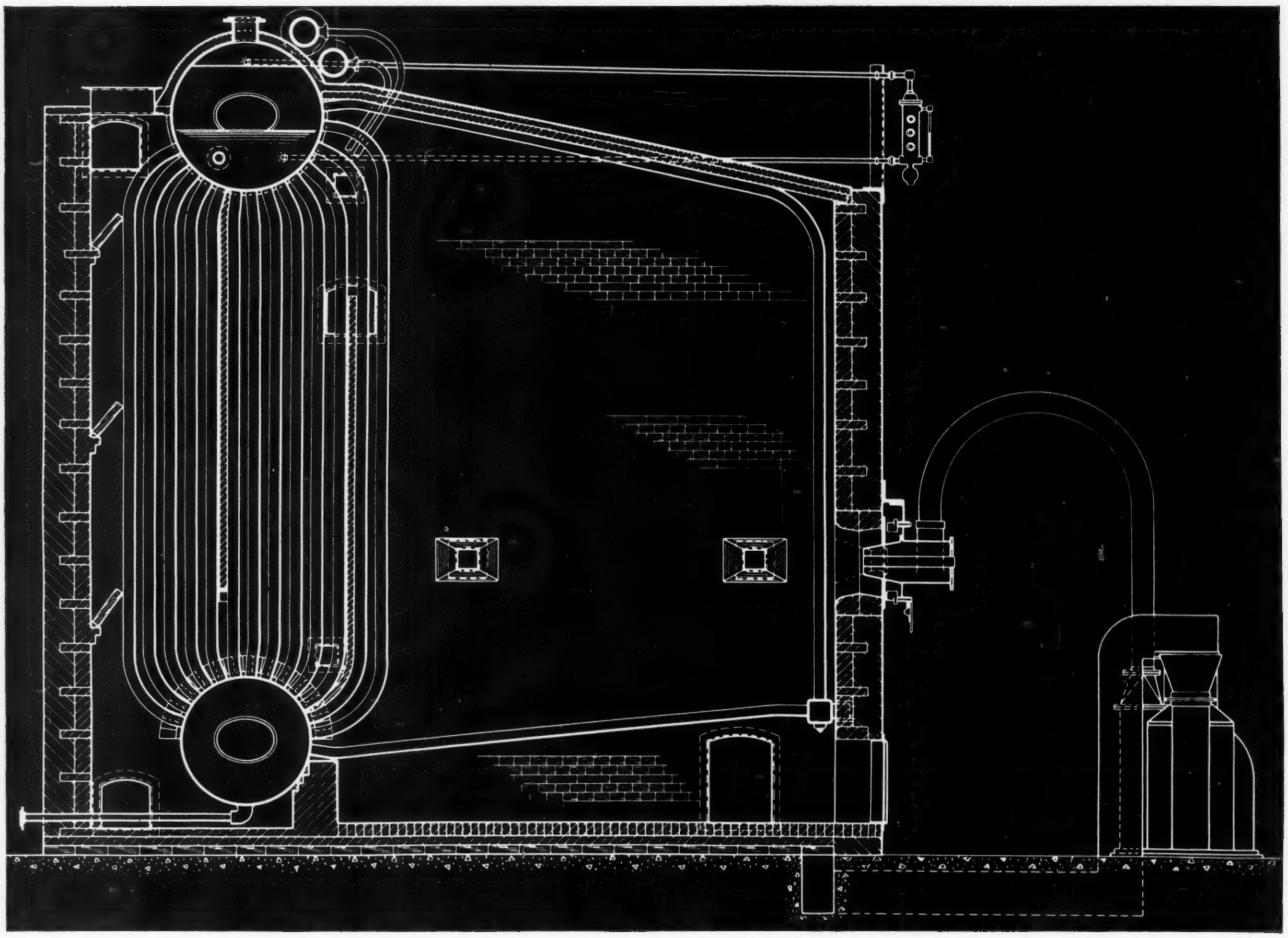


The performance of the C-E Steam Generator Unit is backed by the organization

that has installed

- —the largest boilers in the world
- —the highest pressure boilers in America
- —the largest high pressure boilers in the world

that leads the field

- —in number of mechanical stokers installed under power boilers
- —in number of box header boilers installed
- —in amount of boiler surface equipped for pulverized fuel firing.

that

- —made the largest boiler installation placed in service in 1932
- —received the largest single order for steam generating equipment in 1932

FEATURES

ECONOMICAL

in first cost and operation

COMPACT

low head room and small floor space

PULVERIZED-FUEL, OIL or GAS FIRED

with the consequent advantages of

wide choice of fuels

no banking losses

ability to pick up or drop load quickly

high average efficiency

Commentary by Joseph H. Keenan

Temperature Scales

Temperature may be defined qualitatively as a quantity which is the same for all bodies which can be brought into thermal contact without a net heat flow occurring from any one to any other; and a body from which heat will flow to this first group of substances is at a higher temperature. In fact the purpose of a temperature scale is to indicate the direction in which heat will flow if two bodies are brought into thermal communication.

Since mercury expands when heat flows to it and contracts when heat flows from it, an obvious way to indicate temperature, is to magnify the change in volume of mercury confined in a bulb by bringing its surface into an extended capillary tube. If the mercury bulb is one of the first group of bodies the surface of the mercury thread will come to rest at a definite position. If it is brought into contact with the second, hotter, body the mercury will rise in the capillary to a higher position. By taking two reference bodies, say melting ice and boiling water, we can divide the interval between the mercury levels corresponding to equilibrium with the two bodies into as many subdivisions as we wish, and call each a degree.

The expanding liquid thermometer, which dates back at least to Galileo, has some obvious disadvantages. For instance, what shall be our temperature scale below the freezing point of our thermometric liquid, or above its boiling point? If the liquid has, like water at 4 deg. cent., a reversal in the direction of volume change, then the same level in the stem might indicate two different temperatures.

Early in the history of thermodynamics it was found that the volume of all the more permanent gases changed in the same proportion, within experimental error, for the same change in temperature. Here was something with cosmic significance, a temperature scale defined equally well in terms of several different substances. But the cosmic significance was soon marred by the development of experimental technique which proved that gases as permanent as hydrogen and nitrogen yielded slightly different scales of temperature.

Then Carnot proclaimed a new principle, a simple concept which slowly extended its significance through corollary after corollary until it constituted the fabric of a science. Carnot said, in effect, that a heat engine consisting of a completely reversible cycle of operations, taking heat from a reservoir at one temperature and discharging heat to a reservoir at lower temperature, will deliver the maximum quantity of work, per unit of heat taken in, that can be delivered continuously by any heat engine working between those two temperature limits. The proof is simple: if an engine more efficient than the reversible engine can be devised, then the reversible engine can be reversed and made to deliver heat to the high temperature side of the other engine, dispensing with the high temperature reservoir. The second engine, by virtue of its supposedly higher efficiency, now delivers work in excess of that which must be delivered to the reversed engine. There is a net cooling of the low temperature reservoir which equals quantitatively the net work output of the combined engines. The process now constitutes perpetual motion of the second kind, that is, complete conversion of heat from a single reservoir into work. All human experience with heat engines indicates such a process to be impossible.

Now, two reversible engines working with different fluids must deliver the same amount of work per unit of heat received, otherwise by reversing the less efficient one we should again have perpetual motion of the second kind. This in turn leads to the possibility of defining a temperature scale which is the same regardless whether the thermometric substance is hydrogen or helium, chewing gum or cheese. Lord Kelvin proposed defining the relation between the temperatures of any two heat reservoirs as the ratio of the heat taken from the higher one by a reversible engine to the heat delivered to the lower one by the same engine. Since the difference between the two heat quantities is the work done, the Kelvin scale is in reality defined by the efficiency of the reversible engine. An arbitrary assignment of one hundred degrees to the interval between the ice and boiling points of water at atmospheric pressure completes the definition.

The Kelvin scale finds its justification not in its approximation to its predecessors, but in its simplification of thermo-dynamic relationships. Today the basic temperature scale for all scientific work is the Kelvin scale, and our fundamental thermometer is a strange heat engine of unattainable efficiency.

Joseph H. Keenan

Stevens Institute of Technology

Note: Professor Keenan will continue his discussion of temperature next month.

ANNOUNCEMENT

SHEPPARD T. POWELL

COMBUSTION announces a notable series of articles on Boiler Feedwater and related subjects to begin in the April issue. The author, Sheppard T. Powell, Consulting Chemical Engineer, Baltimore, has given us the following list of titles which are indicative of the scope and content of the series.

Slime and Mussel Control in Surface Condensers and Circulating Water Tunnels

Droughts and Their Influence on the Quality of Water for Industrial Uses

A Critical Study of Boiler Scales and Advanced Methods of Analyses and Identification

Impure Steam—Its Cause and Prevention

Analytical Control of Boiler Feedwater Conditioning

Recent Trends in Boiler Feedwater Control

Corrosion in Steam Generating Stations and Its Correction

The Use of Electric Control Apparatus in Boiler Feedwater Treating Systems

Boiler Feedwater Research in America and Europe—A Critical Review

Continuous Boiler Blow-Down Equipment

Failures of Boilers Due to Cracking, Where They Occurred and What It Has Cost

Chemical Treatment of Boiler Waters—Past, Present and Future

For the benefit of those readers of COMBUSTION who may not be familiar with Mr. Powell's work in this field we give the following information concerning him and his activities.

He received his technical education at the Rensselaer Polytechnic Institute, Troy, New York, specializing on water purification, sewage and trade waste treatment, and other related subjects.

From 1908 to 1912 he was Chief Chemist for the Baltimore County Water & Electric Company. Since that time he has been actively engaged in consulting work. He has been associated with numerous large public utilities and industrial corporations, serving in a consulting capacity on the design and operation of water purification systems for high pressure steam stations and the elimination of trade waste.

In recent years he has served as technical expert in a number of important legal cases and in 1930 was the industrial expert for the State of New Jersey in the injunction suit before the U. S. Supreme Court, involving New Jersey, Pennsylvania and New York, relative to the proposed diversion of the Delaware River by the City of New York.

At present, in addition to his work as a consultant, he is Associate in Sanitary Engineering, School of Hygiene (Graduate School), Johns Hopkins University.

Mr. Powell is Chairman of the Executive Committee of the Boiler Feedwater Studies Committee now conducting research at a number of universities. This group is sponsored and financed by six of the major engineering organizations. He is a past Chairman of the Maryland Section of the American Chemical Society; Vice Chairman of the Four States Section of the American Water Works Association; and a member of the Advisory Committee on the standardization of water analyses for industrial uses, sponsored by the American Society for Testing Materials.

He is a member of the American Institute of Chemical Engineers; Fellow of the American Public Health Association; Member of the American Society for Testing Materials, American Gas Association and other technical organizations.

Mr. Powell has written a number of papers and monographs on chemical engineering and problems on environmental sanitation and is the author of the text book, "Boiler Feed Water Purification."

EDITORIAL

Trends in Boiler Design

A STUDY of the history of boiler designs reveals an amazing fertility of ideas, a great many of which have never gotten beyond the stage of inventors' dreams. The most modern boiler plants of today are still using the conventional designs invented many years ago. While these designs have been improved upon with respect to methods of construction, materials used, baffling and disposition of heating surface, they are for the most part basically unchanged.

An interesting sidelight on boiler invention has been the marked tendency of established boiler manufacturers to move very cautiously in sponsoring new ideas, especially those of a radical nature. While this policy may, at times, have seemed over-conservative, in the long run it has probably saved much grief and expense not only for the manufacturers but also for boiler users.

In the past decade, development has proceeded at an accelerated pace due principally to improvements in the arts of combustion, furnace design and construction, and to contemporary demand for higher pressures, temperatures and capacities,—all of which have tended to force progress in boiler design. Still the boiler designs in commercial use have conformed to conventional practice modified to adapt them to the new conditions of service.

Now we are in a period where there seems to be a recrudescence of designs which represent more or less radical departures from conventional practice. Of course there have been isolated designs over a considerable period of time which constituted marked deviations from generally accepted ideas but for the most part these have been very limited in their application and have not found wide use. Examples are the Benson, Loeffler, Borsig, Schmidt and Atmos boilers, all of which have been designed for very high pressures.

Typical of the more radical designs for moderate pressure conditions produced in the past two or three years are the Brown Boveri steam generator, the Vorkauf steam generator and the Zoelly steam generator. Another rather novel design but one that is limited to high pressures is that of the recently announced Sulzer, single-tube steam generator.

The Brown Boveri steam generator comprises, in series, a combustion chamber, water heating surface in the form of tubes and headers, a superheater, a turbine and an economizer. The turbine operates compressors which supply a mixture of air and gas to the combustion chamber at a pressure of about 28 lb. per sq. in. The combustion gases leaving the superheater at a fairly high temperature are expanded through the turbine and discharged to the economizer.

The Vorkauf steam generator is a most unusual design in which the heating surface is comprised of tube loops which are rotated rapidly by a turbine, both turbine and tube loops being mounted on the same shaft. No boiler feed pump is required since the rotating loops have water in one leg and steam in the other and the resultant unbalanced centrifugal forces create the necessary pressure.

The Zoelly steam generator is of somewhat more conventional design. However, like the two previously mentioned units, it has no drums. The heating surface is composed of vertical tubes made up of short sections welded together. The diameter of each tube is graduated uniformly throughout its length, the large diameter being at the top end from which the steam is collected and delivered to a superheater.

The Sulzer steam generator is designed for high pressures and consists of a single continuous tube comprising successively: economizer, boiler and superheater zones. Drums, headers and downcomers are eliminated. This unit, like the Benson boiler, requires exact coordination of heat liberation and water circulation; hence completely automatic regulation is necessary.

The fact that several such novel designs have been brought out within a comparatively short time would seem to indicate a feeling on the part of some boiler designers that further progress lies in the direction of distinctly new conceptions. Whether these particular designs will achieve any large measure of success remains to be seen, but they are decidedly interesting and are indicative of a revival of the pioneering spirit in the field of boiler design.

In order that readers of COMBUSTION may have the opportunity of familiarizing themselves with these new trends in boiler design, complete descriptions and illustrations of several of these designs will be presented in an article to be published shortly.

Using Mine Refuse as Boiler Fuel

THE first article in this issue furnishes an example of a situation that probably exists in a number of coal mine properties. There are many mines that have installed cleaning and preparation facilities within the past few years and many others that have extended and improved existing facilities for making their product more marketable. Where such mines are not making profitable use of the refuse from their cleaning and preparation plants, it will be greatly to their advantage to investigate the economies that can be effected by installing modern boiler plant equipment permitting the use of this otherwise valueless fuel.

These economies will be particularly attractive where steam requirements are large and the installation of a new plant will permit taking out of service a number of relatively small boilers in older plants. The fuel used for firing such boilers is generally of a type that can be sold at a profit, and the resultant overall economies will quickly pay for the new installation.

Such opportunities for substantially reducing operating costs should not be overlooked even in the present difficult condition of the coal industry, especially since they lend themselves to definite dollar and cents analysis.

Large Anthracite Mine Installs Central Steam Plant

The story of the new central steam plant, recently completed at the St. Nicholas breaker of the Philadelphia and Reading Coal & Iron Company, is an exceedingly interesting one. The two boiler units in this plant supply steam to several collieries each of which previously had its own boiler house containing a number of hand-fired h.r.t. boilers. These boilers required marketable sizes of steam coal, whereas the new units burn very small sizes which formerly had been lost in the colliery breakers. Since the two new boilers have been placed in operation the several old boiler houses have been shut down . . . . The accompanying article reviews the conditions which led to the decision to build a central steam plant, and describes the plant, its operation and the steam distribution system.

BEFORE describing the new central steam plant recently completed at the St. Nicholas Breaker of the Philadelphia and Reading Coal and Iron Company, it may be of interest to review some of the developments leading up to the construction of this plant.

The Philadelphia and Reading Coal and Iron Company, the second largest producer of anthracite in the United States, has for some time past, been carrying on an extensive program of improvement of its preparation facilities. The Company's previous practice had been to prepare the various sizes for market from the run-of-mine anthracite in the breaker at each colliery, of which it has some twenty or more. In 1930, a central breaker was placed in operation near Mt. Carmel, Pa., into which a number of collieries shipped, by rail, run-of-mine coal that had been given a preliminary cleaning at the shipping colliery to remove rock and other foreign material. The success of that central breaker warranted the construction of another one which was completed during the past two years at St. Nicholas, Pa. The latter breaker is about centrally located in what is known as the Mahanoy Division. It receives freshly mined coal by rail from the Mahanoy City, Gilberton, Shenandoah City, West Shenandoah and Hammond collieries, each of which does preparatory cleaning. It also receives coal from the cleaning plant at the nearby Maple Hill colliery which plant cleans the coal from its own colliery shafts and that mined at the St. Nicholas, Knickerbocker and Ellangowan collieries. Coal from the St. Nicholas colliery is hoisted up a slope into a loading house and travels to the Maple Hill cleaner plant over a traveling belt conveyor. The product of this cleaner plant is moved to the St. Nicholas central breaker by a motor-driven belt conveyor, 1013 ft. long. It is of interest to note in passing that the refuse from the Maple Hill cleaner plant and from the central breaker is removed to rock loading hoppers by similar belt conveyors, 944 ft. long and 836 ft. long respectively.

It is the practice at the Company's collieries to develop the power required for hoisting coal, pumping water out of the mines, ventilating the workings, compressing the air necessary for mining operations and all the auxiliary services by the use of steam. The steam is generated in 125 hp., 100-lb. pressure, hand-fired h.r.t. boilers, and each colliery has its own boiler plant comprising a number of these boilers set in batteries of two each. From these plants steam is transmitted in pipe lines to the various steam engines.

Fig. 1—St. Nicholas central breaker. New steam plant can be seen in middle background.

As a result of this practice, there has been accumulated an immense investment in steam-driven equipment, especially suited and of proven worth to anthracite mining, which could not be ignored in any modernization program.

In the valley at St. Nicholas there were similar boiler plants at the St. Nicholas, Maple Hill and Ellangowan collieries, all relatively near one another. Each served a pipe-line distribution system for its respective colliery. The completion of the St. Nicholas Central Breaker created a new demand for steam in the valley. The breaker circulating water pumps are turbine driven and take about 25,000 lb. of steam per hr. A thaw shed in conjunction with the breaker affords another large block of steam load.

The known anthracite reserves owned by the Company around St. Nicholas and the development program for all of their mines, warranted the serious considera-

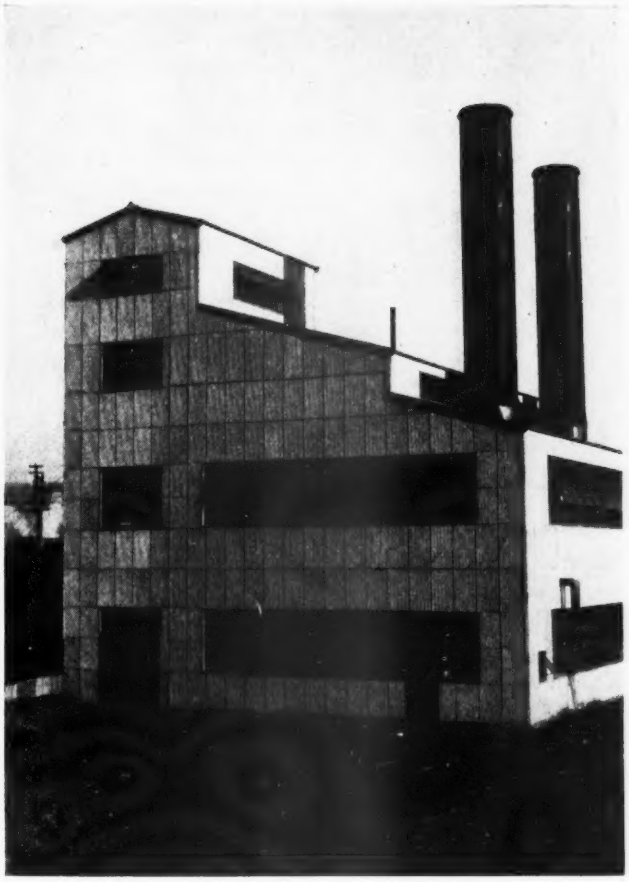


Fig. 2—St. Nicholas Central Steam Plant

tion of centralizing the generation of steam for the entire valley. The conclusion was reached that a boiler plant located at the load center would justify itself economically. In the fall of 1931, action was initiated to build and complete such a plant to carry the 1932-33 winter load, the first winter the St. Nicholas central breaker would be in operation.

The first fundamental requirement of the new boiler plant was simplicity and ruggedness of the equipment making for continuity of service. High, but reliable, capacity from each boiler unit was essential. Efficiency, not to be totally overlooked, was of secondary consideration because of low-priced fuel.

The older boiler plants used as fuel the rice and barley sizes of anthracite on hand-fired grates. Both of these sizes enjoy a ready market as steam coal. It was desired that the new central steam plant use a still smaller size known as buckwheat No. 4 for which a market is being developed. It is a new size and as a practical fuel has been produced only in the central breakers where its recovery is possible and the ash content is controllable. Heretofore, this size has been largely lost in the colliery breakers and it has been pumped out on the slush banks.

The second fundamental requirement then was that the new boiler plant utilize as fuel buckwheat No. 4 size anthracite, so rice and barley sizes might be released to market. The specifications for this fuel are 15 per cent moisture, 13 per cent ash and 10,850 B.t.u. per lb. as fired. Sulphur content, separately determined, is 0.5 per cent. The sizing specification is as follows:

Over 3/32 in. mesh	1 to 2 per cent
Through 3/32 in. mesh over 1/16 in. mesh	12 to 15 per cent
Through 1/16 in. mesh over No. 20 mesh	19 to 23 per cent
Through No. 20 mesh over No. 30 mesh	30 to 38 per cent
Through No. 30 mesh over No. 50 mesh	17 to 21 per cent
Through No. 50 mesh	8 to 14 per cent

The load which the new plant would have to carry is a widely varying one. Between the days of the year there are distinguished working and idle days, depending upon whether the adjacent collieries and central breaker are in production or are idle. There are about 250 working days a year, the balance being idle. Each day is divided into three eight hour shifts, beginning at 7:00 A.M. The first shift from 7:00 A.M. to 3:00 P.M. is the working shift when coal is hoisted and all of the services supplied by the central steam plant are in demand. The second shift ending at 11:00 P.M. affords a lighter load than the first shift because, while there are some mining activities underground, coal is seldom hoisted. The third shift is a light load as only essential services are carried on.

The load also varies seasonally. The winter load is the heaviest, that during the summer months the lightest and during spring and fall the load is somewhere between these two extremes. It is evident at once that the load is anything but a base load, not only does it vary considerably on different shifts and during different seasons but it fluctuates from minute to minute because of the sudden and large demands made on it by the steam hoisting engines serving three shafts, a slope and a plane, to say nothing of the normal variations in the demands of the other services.

The load as now made up does not involve any mine pumping. Practically all of the mine water gravitates to a pump at Maple Hill colliery and is pumped to the surface by electrically-driven pumps installed in the summer of 1932. When it is recalled that about twelve tons of water must be removed from the mines for each ton of anthracite produced, it is apparent, that a large block of load has been spared the steam plant.

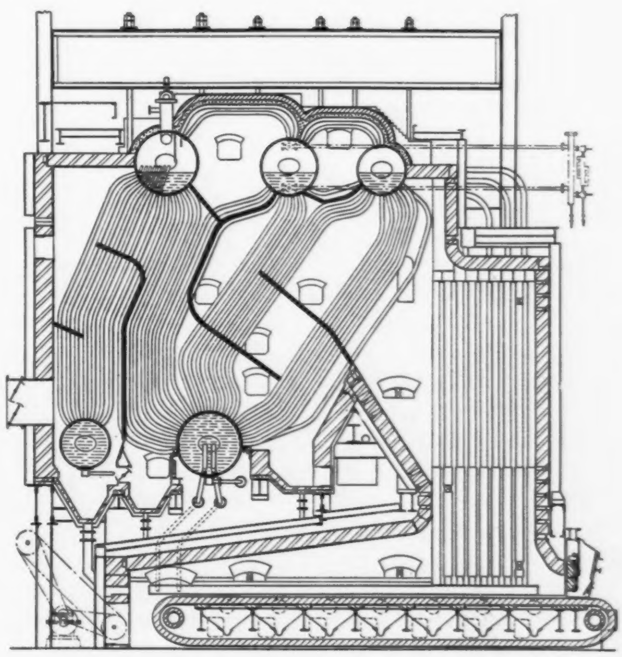


Fig. 3—Cross section of one of the two boiler units.

The choice of working steam pressure for the central steam plant was dictated by these considerations (a) it must be high enough to transmit through lines to points half a mile away and minimize their size within reasonable pressure drops and economic limits, (b) it must not be so high as to require excessive investment in boiler pressure parts and (c) it must be such as will give at least 100 lb. pressure at the steam-driven units after all line losses and a severe drop in generating pressure in the new plant are given effect. A working pressure of 430 lb. per sq. in. was selected as the optimum.

The product of the new boiler plant is distributed by two outgoing distribution lines. One line goes north to supply the Maple Hill and Ellangowan collieries. The other line goes south to serve the thaw shed, St. Nicholas central breaker and St. Nicholas colliery. The north line is of 10 in. dia. to the Maple Hill colliery, a distance of about 500 ft., and supplies steam at boiler pressure less line drop to three reducing pressure valves which lower the pressure to 110 lb. for local distribution in the colliery's existing piping system. It then continues as an 8 in. line about 1850 ft. to the Ellangowan colliery where another reducing pressure valve station is located. Here two reducing valves drop the pressure to 110 lb. for similar local distribution. The south line is also 8 in. dia. and runs 1675 ft. to a two valve pressure reducing station located in the central breaker. Off this line, operated at over 400 lb. pressure, are two branches, one serving the thaw shed heaters and another supplying steam at line pressure to the turbines driving two circulating water pumps in the central breaker. The exhaust from these turbines is used to heat the breaker. The low pressure side of the reducing valves supplies 100 lb. steam to the St. Nicholas colliery located east of the central breaker. The 400-lb. steam transmission lines are of all-welded wrought iron construction, no flanges being used except at the principal flanged valves. They are suspended overhead on wrought-iron pipe supports set in concrete piers, amply provided with anchors and expansion loops, adequately drained through high pressure traps and thoroughly heat insulated. There has not been sufficient operating experience with these lines to warrant any conclusions as to their ultimate success, but the quality of materials and workmanship combined with the design of the lines should assure their satisfactory operation.

Careful estimates of the load the new plant would carry were made based on the demands on the existing boiler plants and the new loads incident to the central breaker and thaw shed operation. The combined load revealed a peak demand of about 200,000 lb. of steam per hr. It was decided that two steam generating units would be required to carry this load. A spare unit was not thought essential as it is proposed, during the first year's operation at least, to maintain the 14 h.r.t. boilers in the Maple Hill boiler house in a standby condition in the event of a major outage of either of the two new boilers. Then, too, it was desired to minimize the investment in and consequent fixed charges on the new plant.

The foregoing briefly outlines the background for the construction of the St. Nicholas central steam generating plant. Preliminary studies were completed in November, 1931, and design work was started a month later. Ground was broken on April 15, 1932, and construction proceeded during the ensuing summer. Initial operation started on September 25, and on November 1, 1932, the plant was carrying all the available load and the old boiler houses were shut down.

In detail, the central plant comprises two boiler units. Each is a Class XXII-Special, No. 36 Stirling boiler containing 11,062 sq. ft. of heating surface. Extra tubes in the rear bank and a fifth drum comprise an integral economizer having 3459 sq. ft. of surface. As shown in Fig. 3, the only water-cooled walls are panels, 8 tubes wide, in each side wall opposite the throat of the arch. The bare tubes extend the full height of the setting. The lower water-wall boxes extend from front to rear of the furnace immediately above the ledge plates of the stoker. The five drums of each boiler are of all-welded construction. The arches are of refractory material without water cooling. The furnace volume is approximately 4000 cu. ft.

As will be seen in Fig. 3, the boiler baffling differs from conventional baffling for this type of boiler. The objective sought was a lower draft loss through the setting and that objective has been accomplished. Any boiler fired with the smaller sizes of anthracite will have a large amount of fines carried over from the fuel bed into the gas passages, especially if forced draft is used. The St. Nicholas boilers are no exception in this respect. However, an inspection made after the first 90 days of operation showed that the gas velocities were such as to sweep clean the heating surfaces and deposit the carry-over into the hoppers as shown in Fig. 3. The carry-over from the second pass hopper and from that between the two lower drums is returned by chutes to the fuel bed while that from the other two hoppers is discharged to the ash sluice as the quantities involved are not large and do not result in a considerable unburned carbon loss. This arrangement minimizes the amount of fly-ash and fines emitted from the stacks. The combination of baffling and clean heating surfaces has re-

Fig. 4—One of the two traveling grate stokers.

sulted in much lower exit gas temperatures than predicted by the manufacturers.

The firing equipment consists of Coxe traveling grate stokers, each of 424.5 sq. ft. effective grate area, especially designed to burn efficiently the No. 4 buckwheat size of anthracite previously described. Each stoker is 18 ft. wide, has seven compartments with air control dampers on each side and sifting removal jets to clean all compartments and has a fuel burning capacity of 15,000 lb. of No. 4 buckwheat per hr. continuously and 20,000 lb. per hr. for a period of two hours.

The stokers are driven by 16 hp. steam turbines through belt drives and speed reduction gearing. Each stoker has its own drive for flexibility in operation, but one turbine will drive both stokers, developing full power with as low as 300 lb. throttle pressure in an emergency. The stoker speeds are adjusted manually in accordance with steam pressure.

Turbine-driven forced and induced draft fans furnish mechanical draft in the conventional manner. All the fans are under the Smoot system of automatic control to maintain the conditions selected, irrespective of variations in steam pressure, but the loading on the regulators is applied manually. The induced draft fan, 125,000 c.f.m. capacity, maintains at all times a negative pressure in the furnace at the point at which the control is taken. The forced draft fan handles 67,000 c.f.m. of air at 80 deg. fahr.

With the exception of condensate returns from the thaw shed during the winter months and the exhaust steam from the plant's auxiliary drives, all of the boiler feedwater is make-up. The primary source of supply is the mains of the Anthracite Water Company. Floating on the main, but inside of the Water Company's meter for the central steam plant is a 350,000 gal. covered storage tank. Water is supplied directly to a 300,000 lb. capacity deaerating heater, passing through its vent condenser, is heated in the deaerator and drops into a surge tank to which the boiler feed pump suctions are connected.

All boiler feedwater is chemically treated to prevent the formation of scale and inhibit corrosion and embrittlement. Each day at about 7.00 A.M., the beginning of the first shift, the water in each boiler is analyzed and the pH valve and oxygen content determined. The examination of the condition of the water is repeated at 1:30 P.M. Based upon the results of this later examination and the probable load in the next 24 hr., Hagan phosphate is added to the boiler water to prevent scale formation, caustic soda to maintain a pH value of at least 8 so that there is sufficient alkalinity to obviate corrosion in the integral economizers, sodium sulphate to prevent embrittlement and sodium sulphite to remove the final trace of dissolved oxygen. The phosphate solution is prepared in a mixing tank from which it flows by gravity into a feed tank. The flow from the latter is directly into the mud drum of each boiler and is controlled by a thrustor valve that opens each time 150,000 lb. of water passes through the feedwater meter. The interval during which the valve is open may be varied to permit changing the quantity of phosphate added at each opening of the valve. The other three chemicals are added continuously by gravity to the water in the surge tank on the suction side of the boiler feed pumps. The flow is controlled by an orifice plate in the line between the mixing tank and the surge tank. The conditioning of the feedwater is under the general supervision of Hall Laboratories, Inc.

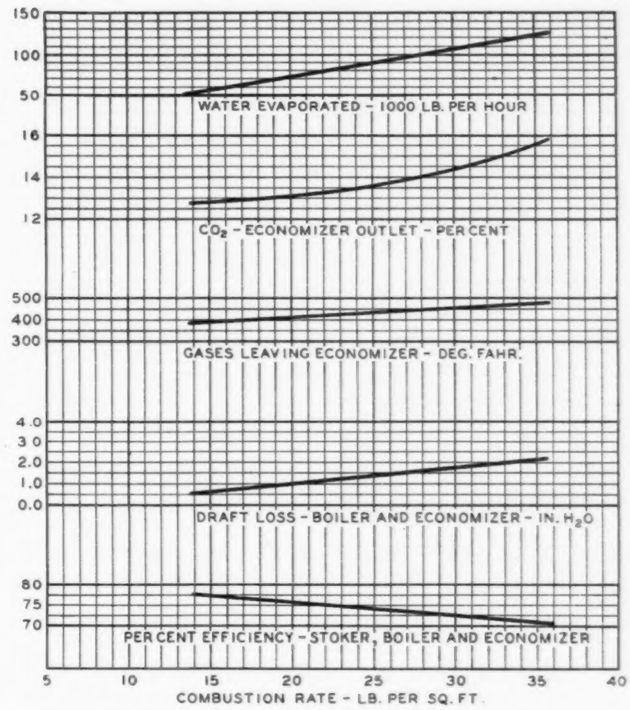


Fig. 5—Curves showing principal test results.

The supply of cold water may be sent directly to the surge tank and by-pass the deaerator or directly to the boiler feed pump suctions in an emergency. Each pump is a 3-in., 3-stage unit, turbine driven, of 350 g.p.m. capacity. There are three such units, one or two of which are spares depending on the plant load.

The method of delivering the No. 4 buckwheat size of anthracite fuel is unique and interesting and may open a new field in the transporation of solid fuels. The fuel is mixed with water at the St. Nicholas central breaker and pumped to the central steam plant through 1800 ft. of 8-in. pipe. The quantity of water involved is 1500 g.p.m. and is constant irrespective of the quantity of fuel being handled. The system is designed for a maximum of 40 tons per hour of solid fuel. Upon arrival at the central steam plant, the mixture of water and solid fuel passes over agitated dewatering screens, the water is shaken out, and the fuel is distributed by a flight conveyor to four bunkers with a combined capacity of 550 long tons. The water is reclaimed and stored in a 350,000 gal. tank from which it is withdrawn for sluicing ashes. Any excess water is returned to the central breaker for re-use. The fuel is allowed to stand in the bunkers at least 24 hr. to thoroughly drain off all water before it is fired. The coal handling equipment is motor driven.

Ashes are dumped over the rear end of the stokers directly into sluice-ways through which water flows continuously. The ashes are dewatered in a hopper, withdrawn from the bottom thereof through an under-cut gate and lifted by a bucket elevator that discharges the ashes onto the refuse belt from the Maple Hill cleaner plant for final disposal on a rock bank.

The building structure is of the conventional steel

frame with Transite corrugated board siding, steel sash windows and red terra-cotta tile roof.

There has not been sufficient operating experience at this writing, to warrant a statement of the boiler unit efficiencies over an extended period. Preliminary tests using buckwheat No. 4 as fuel indicate that the efficiency curve between capacities of 60,000 to 120,000 lb. of steam per hr. is relatively flat. These results are shown graphically in Fig. 5. Daily operating results closely approximate those obtained during the tests. Up to 120,000 lb. output the efficiencies are all above those anticipated, doubtlessly due to ample grate surface and the fact the stokers are not forced beyond the point of maximum efficiency. A better idea of the over-all efficiency of these boiler units will be available a year hence.

The plant was designed and constructed by Stone & Webster Engineering Corporation and is owned and operated by Philadelphia and Reading Coal and Iron Company. Mr. W. S. Johnston is chief engineer of the station and it is to him that COMBUSTION is indebted for much of the factual material and data used in this article.

Data of Principal Equipment

Boilers
Two Stirling, Class XXII-Special No. 36 with integral economizers. Boiler heating surface—11,062 sq. ft., economizer heating surface 3,459 sq. ft., total heating surface 14,521 sq. ft. Pressure 450 lb. per sq. in. Manufacturer—Babcock & Wilcox Company.

Stokers
Two Coxe, size 18 ft. 0 in. x 24 ft. 10 in., effective grate area 424.5 sq. ft. Manufacturer—Combustion Engineering Corporation. Stokers driven by two Moore Steam Turbines, 16 hp., 4097/900 r.p.m.

Forced draft fans
Two turbovane, 67,000 c.f.m. Driven by 90 hp., 1200 r.p.m. turbines. Manufacturer—B. F. Sturtevant Company.

Induced draft fans
Two steel plate, 8 ft. dia., 125,000 c.f.m. Driven by 260 hp., 4200 r.p.m. turbines with gear transmission providing a speed range of 4200/600 r.p.m. Manufacturer—B. F. Sturtevant Company.

Automatic fan control
Speed control system for regulating forced and induced draft fans. Manufacturer—Smoot Engineering Company. Air blower for Smoot system, Stacey Engineering Company, 5 c.f.m. Air blower motor, General Electric Company, 2 hp., 865 r.p.m.

Boiler feed pumps
Three 350 g.p.m., 1260 ft. t.d.h., 3550 r.p.m. Manufacturer—Worthington Pump & Machinery Corporation. Driven by three 180 hp., 3550 r.p.m. B. F. Sturtevant turbines.

Booster pump
500 g.p.m., 75 ft., t.d.h. 1750 r.p.m. Manufacturer—Ingersoll-Rand Company. Driven by General Electric motor, 15 hp., 1750 r.p.m.

Auxiliary air compressor
14 c.f.m. Manufacturer—Ingersoll-Rand Company. Driven by General Electric motor, 5 hp., 1735 r.p.m.

Deaerating heater
Capacity 300,000 lb. per hr. Manufacturer—Elliott Company.

Dewatering screen
Capacity, 40 tons fuel per hr. Manufacturer—Heyl & Patterson, Inc.

Flight conveyor
Capacity, 66 tons fuel per hr. Manufacturer—Webster Mfg. Company.

Weight larry
Capacity, 4500 lb. Manufacturer—Webster Mfg. Company.

Power Engineers to Participate in Engineering Week

Plans for the huge conference of engineers during Engineering Week, June 25-30, of the Century of Progress Exposition are making excellent progress. Power engineers will be particularly active during the week at sessions of the A.S.M.E. at the Palmer House, and at the exhibits of the World's Fair and the Power Show at the Coliseum.

Preliminary plans for the national meeting of the American Society of Mechanical Engineers call for sessions on fuels, and various phases of central station and industrial power plant practice. In addition to the meetings of the A.S.M.E. some twenty of the national engineering societies will participate with sectional and national meetings.

During the week prior to Engineering Week the American Association for the Advancement of Science will meet in Chicago. Many internationally known scientists will participate on the various programs. Dr. R. A. Millikan is arranging a session on the "Application of Physics to Engineering" which will be a joint meeting of a number of the engineering groups with the International Union of Pure and Applied Physics. This session will begin the activities of Engineering Week, Sunday evening, June 25.

Since most of the exhibits at the Century of Progress Exposition will be of a broad educational character, the Midwestern Engineering and Power Exposition becomes an important part of activities of Engineering Week. At this Chicago Power Show engineering developments will be interpreted in terms of individual manufacturers' products. Some 200 companies will show their latest equipment for the efficient production and utilization of power.

The combined membership of the engineering groups participating in Engineering Week is 91,600. Preliminary estimates of attendance indicate the largest gathering of engineers in history.

The Plibrico Jointless Firebrick Co., Chicago, Ill., announces the appointment of the Geo. L. Simonds Co., Winter Haven, Fla., as their distributor for Plibrico Jointless Firebrick, Demon High-Temperature Cement, and other refractory products.

Mr. Simonds will maintain warehouse stocks of these refractory materials at Jacksonville and Tampa, and will furnish complete installation and boiler setting service.

The Coppus Engineering Corporation, Worcester, Mass., announces that H. M. Gassman, Birmingham, Ala., has been appointed sales representative in the Alabama territory for Coppus-Annis Dry Type Air Filters, the latest addition to the line of the Coppus Engineering Corporation. For many years Mr. Gassman has been sales representative in that district for Coppus Blowers and Steam Turbines. Coppus-Annis Air Filters are made for both industrial and ventilating purposes, and both lines will be handled by Mr. Gassman.

Modern Trends in the use of Wood Waste for Fuel

By HARRY S. BASTIAN, Portland, Oregon

This is a particularly informative discussion of the combustion problems involved in the burning of hog fuel. The author begins by describing the strangely varying characteristics of this fuel and then considers the effects of these characteristics on furnace design. Much practical information is given on furnace and grate sizes and proportions, arch design, the use of forced and induced draft, etc. The radiating capacity of hog fuel gases, an especially notable property of this fuel, is considered at length. Engineers interested in the use of hog fuel will find this article a valuable guide.

MUCH has been written about the use of wood waste, commonly known as "hog fuel", for steam generation; its origin, cost, chemical composition, fuel value, etc., having been the subject of numerous published writings. Nevertheless, the extreme complexity of hog fuel combustion phenomena admits of almost unlimited study. Particularly is this true in view of the trend of design of modern steam generating equipment, with water-cooled furnace walls, radiant type superheaters, air preheaters, mechanical draft, etc., all occupying important positions in the art. It is interesting to note that the peculiar characteristics of hog fuel conform quite well to the demands of these modern developments, although the contradictory nature of these characteristics makes it difficult to state in exact terms the data relative to the use of this fuel, since we are dealing with:—

(1) A solid fuel that acts as a gas, and should be treated as such, both in furnace design and in its combustion.

(2) A fuel that evaporates a ton of water in the furnace while evaporating three tons in the boiler.

(3) A fuel that has the lowest heating value of all commercial fuels, yet which is abnormally destructive to furnace brickwork.

(4) A fuel that has the lowest heating value, yet which produces a higher superheat and preheated air temperature with equivalent equipment than does the fuel with the highest heating value (oil).

(5) A fuel that contains about one-tenth as much available heat per cubic foot as ordinary steam coal, yet can produce equivalent ratings in furnaces of equivalent dimensions.

(6) A fuel that requires more air for combustion than either coal or oil, yet which can use forced draft only to a limited extent.

(7) A fuel that is devoid of corrosive flue gases, yet which under certain conditions may be extremely destructive to air preheaters, induced draft fans, breechings, etc.

It is quite evident that in dealing with a fuel embodying such contradictory characteristics many of our accepted ideas of furnace engineering must be radically altered. A fuel that has a proximate analysis like this:

(Douglas Fir)

Moisture	47.0 per cent
Volatile Combustible	39.7 per cent
Fixed Carbon	11.7 per cent
Ash	0.7 per cent
B.t.u. per lb., as fired	8970
B.t.u. available as fired	4100

obviously requires special treatment. Nearly one-half of the fuel is moisture, a greater thief of heat than excess air. Nearly 40 per cent of the total, or 80 per cent of the combustible, is volatile, which we can reasonably assume is gasified before being burned. Less than 12 per cent of the fuel as fired is fixed carbon.

The bulk of the fuel is also unprecedented:—18 to 22 lb. per cu. ft. as fired, as against 80 to 90 lb. for coal as fired, does not make for compactness in handling. Or, judged from a slightly different angle, hog fuel contains less than 10 per cent as much available heat value per cubic foot as does a good grade of bituminous coal. Therefore to get anywhere near the ratings obtained from other fuels without abnormally large furnaces, high speed ignition and combustion are essential, and it is worthy of more than passing note that these results are actually being obtained. It is obvious, however, that any considerations of the design of furnaces are drastically affected by these peculiarities.

One of the most important principles of furnace performance, and one that has but recently been given the study its importance justifies, is the application of the phenomenon of radiation. It is beyond the province of this article to discuss the technical details of furnace radiation, but its importance in furnace design and operation is becoming more and more apparent, and modern furnace engineering is becoming increasingly influenced by its principles. Hog fuel, more than any other commonly used fuel, emphasizes the importance of radiation for its efficient utilization, for the following reasons.

It is a well established fact that of all the gases mak-

ing up the ordinary products of combustion, carbon dioxide and water vapor alone are capable of absorbing and emitting heat by radiation, and these can radiate heat to a colder surface even when non-luminous. Now it can be shown (Table 1) that the quantities of CO_2 and H_2O gases from hog fuel is about three and one-half times that from coal or oil per pound of steam generated, and 30 per cent more per pound of fuel burned. Since modern steam generating equipment is more and more being designed to absorb heat by radiation, this unique characteristic of hog fuel cannot be overlooked.

TABLE 1

COMPARISON OF FLUE GASES GENERATED BY THE COMBUSTION OF COAL, OIL, AND HOG FUEL

	Ultimate Analysis		
	Coal per cent	Oil per cent	Hog Fuel per cent
Carbon	77.61	84.00	26.22
Hydrogen	4.88	12.70	3.09
Oxygen	4.15	1.20	22.61
Nitrogen	1.81	1.70	0.03
Sulphur	1.14	0.40	....
Ash	7.60	....	0.15
Moisture	2.91	....	47.90

Amount of radiating gases in products of combustion from above fuels, per pound of fuel fired:

	Coal		Oil		Hog Fuel	
	Lb.	per cent	Lb.	per cent	Lb.	per cent
CO_2	2.929	18.22	3.088	14.959	1.845	18.49
H_2O	0.481	3.00	1.143	5.537	1.037	10.40

The true measure of importance of these gases is the relative quantity produced per pound of steam generated, as shown by the following tabulation:

	Coal Lb.	Oil Lb.	Hog Fuel Lb.
Evaporation per lb. of fuel, F. & A., 212 deg.	11.7	15.1	2.99
CO_2 per lb. of steam	0.250	0.204	0.617
H_2O per lb. of steam	0.041	0.075	0.347
Total of both gases	0.291	0.279	0.964

The dutch-oven type of furnace has been found by far the best suited for the efficient combustion of hog fuel, but the design of the furnace should follow a few well established rules, all dictated by the peculiar nature of the fuel. Here again, radiation plays the leading role. Hog fuel being largely volatile, the oven should and does act much as a gas producer, the final combustion taking place in the chamber back of the furnace. This gasification is caused largely by radiated and reflected heat from the overhanging furnace arch acting on the surface of the fuel pile; in fact a basic principle governing dutch-oven design is that hog fuel firing is surface combustion. In all dutch-ovens the fuel is fed through one or more holes in the top and falls on to the cone-shaped incandescent pile on the grates. This is distinctly an overfeed principle, and with a fuel as volatile as hog fuel much combustible would be driven off and wasted were it not for the ignition consequent upon the incandescent overhanging arch. The shape and location of this arch thus becomes a dominant feature of dutch-oven furnace design.

As the fresh hog fuel enters the furnace the moisture and volatile constituents immediately begin to gasify and rise to the roof of the furnace. A considerable proportion of this gas is H_2O, which as we have just seen is capable of absorbing heat by radiation. This has an undoubted effect of cooling the furnace, and in order to keep the arch surface hot enough to gasify and ignite the gases, some combustion should immediately take place. Owing to the fact that these gases tend to pass out of the furnace at a high rate of speed, the air coming up through the fuel bed has little opportunity of catching up with them, and consequently air must be introduced into the furnace over the fuel pile in order to promote proper combustion.

It is reasonable to suppose that not all of the combustible gases generated in the furnace are distilled by the direct action of the heat from the arch. As is pointed out, a hog fuel pile burns largely from the surface. As the volatiles distill off, particles of incandescent carbon or charcoal are left. The water vapor from fresh fuel coming in contact with this incandescent carbon provides all the necessary factors for the generation of water gas. In fact, it is possible to design a form of gas producer that will make a fair grade of water gas by combining the moisture in hog fuel with its fixed carbon raised to the proper temperature by the reactions in the producer itself. All this confirms the original statement that the reactions taking place in the combustion of hog fuel are exceedingly complex, presenting in general the anomaly of a solid fuel requiring treatment as a gas.

As indicated above, the gases when generated pass out of the furnace at a rate of speed that causes them to traverse the entire length of the dutch oven and reach the comparatively cool boiler and water-wall tubes in a very short space of time. This speed is high owing to the large bulk of gas being generated in the restricted space, and which must be removed at the same rate it is generated in order not to build up objectionable positive pressures in the oven. If the combustible gas is not thoroughly mixed with air at the ignition temperature during this brief passage its contact with the tubes may cool it below the ignition point and further combustion is prevented. Remember we are dealing with a fuel, the greater part of which is in motion towards the furnace exit before it is burned, and it must be consumed "in transit." This makes the design of the dutch-oven arch often of more importance than that of the grates. Unless the gas and air are forcibly mixed, the rapid motion causes stratification or "laning" and imperfect combustion results. Since the intensity of the rate of combustion, and the resulting furnace temperature, is a function of the speed of mixing air and combustible, the furnace arch should be designed to promote this mixing as much as possible.

The best means so far found for furthering this action is the drop arch at the furnace throat. The drop arch accomplishes this result by three methods:—first, by forming a pocket in which the hot gases may slacken for a moment their swift motion toward the exit, increasing the available time for combustion; second, by creating a turbulence or mixing action by an abrupt change of direction of flow and a cross flow of gas and air; and, third, by increasing the length of the path of gas travel after emerging into the combustion chamber and consequently the length of available time for combustion.

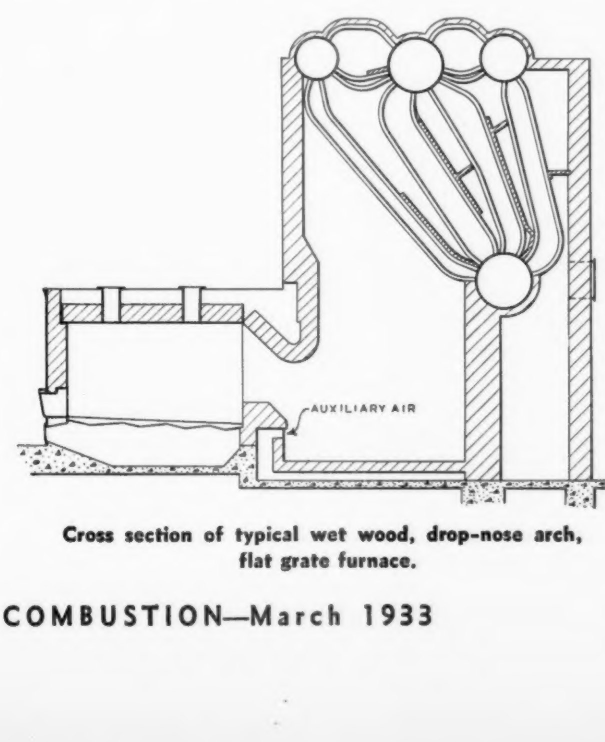
While the function of the drop arch is much like that of any ignition arch, its principle of design is affected by the moisture content of the fuel. Hog fuel may vary

in this respect from the kiln dried fuel, with combustion characteristics similar to that of pulverized coal, to that carrying over 50 per cent moisture. This moisture must be driven off with other volatiles by the radiation from the arch, and the greater the moisture the slower is the process of evaporation, while the greater is the volume of gases to be handled.

With kiln-dried fuel, the speed of combustion is a maximum approaching that of coal; and the velocity of the gases through the furnace is a minimum. Hence there is less need of retardation of the gas flow in order to insure combustion, and since there is no blanket of water vapor arising from the fuel surface the radiation requirement of the ignition arch is a minimum. In this case more combustion takes place in the furnace itself, and the furnace temperature is higher. The drop arch may in this case be almost entirely dispensed with, retaining just enough to insure thorough mixing of gases with the air admitted over the fuel bed.

As the moisture content of the fuel increases, the need for augmenting the intensity of arch radiation also increases. The rear of the fuel pile must be subjected to more direct radiation, the overfire air must be more thoroughly mixed with the gases, and the mixture must be held in the furnace longer to compensate for delayed combustion; this latter function being complicated by the fact that larger volumes of gases are being handled in a space whose volume is decreased due to the necessity of having the arch closer to the fuel bed to aid the effect of the radiation. All this dictates deepening the drop arch as the moisture content of the fuel increases. It also means that a greater proportion of the combustion takes place in the chamber back of the furnace.

If the foregoing principles are correct, it should follow that a furnace designed for dry wood would not successfully burn wet wood, and vice versa. This is borne out by experience, it being found that a wet fuel furnace will smoke and behave badly when fired with dry fuel, and a dry fuel furnace may decline to carry its accustomed load when supplied with wet fuel. Where both kinds of fuel are to be encountered in a plant, and opportunity is lacking to effect a uniform mixture, the furnace design should be a compromise between the two extremes, and the changing fuel characteristics dealt with by varying other operating features, such as overfire draft, depth of fuel bed, secondary air admission, etc. In some intermittent cases of extremely dry fuel, water is sprayed on it to keep down the smoke and more nearly conform to designed furnace conditions. Since most modern installations are for high ratings, difference in fuel quality may more readily be dealt with by the aid of the mechanical draft generally employed.



Cross section of typical wet wood, drop-nose arch, flat grate furnace.

The same principles that cope with variable moisture conditions may also be employed successfully in dealing with different kinds of wood. For example, such slow burning fuels as cedar, redwood and hemlock, act as wet fuels, requiring high draft velocities, deep drop arches, and furnaces employing in their design the maximum degree of arch radiation. On the other hand resinous woods, such as fir, when wet, burn nearly as well as cedar when dry, and a compromise furnace design will generally suffice.

The dutch oven and drop arch perform another important function. Keeping in mind the radiating properties of the gases coming from the hog fuel bed, as well as the radiating capacity of the incandescent fuel surface itself, it is obvious that these gases, by radiating heat to the comparatively cool boiler tubes, would cool the furnace and inhibit the action of the arch in gasifying and igniting the fresh fuel. The greater proportion of the combustible distillates generate gas at well defined, fairly high temperatures, and cooling the furnace below these "critical" temperatures results in a very noticeable drop in boiler output. By screening the tubes from the furnace with a refractory drop arch, the chilling effect of radiation absorption is largely prevented. A known case in point is that of a dutch-oven furnace which had its capacity noticeably increased by removing the grates that were directly under the boiler tubes, comprising about one-third the total grate area, and screening the furnace from the tubes by means of an 18-in. drop arch.

The results obtained from a dutch-oven furnace are very noticeably affected by the distance between the surface of the fuel bed and the face of the arch. The experience of operators has shown that a variation of 20 per cent in this distance, either increasing or decreasing it from the best operating location, has materially affected the capacity of the furnace. This characteristic helps the operator in regulating the performance of his furnace by allowing the fuel bed to drop away from the arch or build up to it as his load decreases or increases, keeping in mind the fact that if the pile gets too close to the arch it has much the same effect as though it were to get too far away, because it pinches off the required combustion space, retards furnace combustion and cools the arch surface.

Fairly definite empirical rules can be established linking area of grate to be served with capacity of boiler, and quality of fuel with boiler width. In order to get a proper admission of air around the edges of the fuel pile without stifling the center, (since we do have some fixed carbon to consume) it has been found that a grate area 6 to 8 ft. square is the best area to be served by a single fuel hole, and an area 9 ft. square is about the limit. For a fuel of average quality, say Douglas Fir with 45 per cent moisture, 12 to 16 in. between the arch and apex of fuel pile should be allowed for maximum

load conditions. In order to get the edges of the grate well covered, this calls for a furnace depth, from arch to grates, of 5½ to 7½ ft., which is about the range of dimensions for the majority of successful hog fuel furnaces.

The required size of a furnace for a given load can likewise be predicted with fair accuracy. A rule, based almost entirely on practice, may be stated as follows:

(a) With a good grade of fairly dry fuel, use one square foot of grate for 50 sq. ft. of boiler heating surface.

(b) With average grade fuel, (say fir with 42 to 45 per cent moisture) use one square foot of grate for about 43 sq. ft. of boiler heating surface.

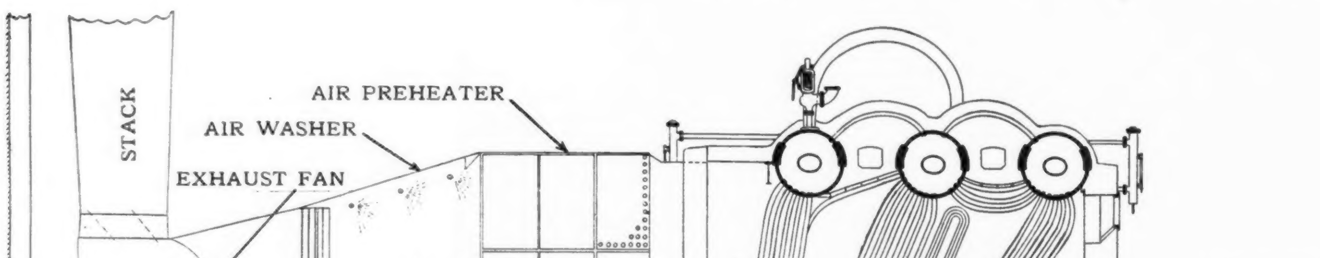
(c) With poor grade fuel, (say hemlock, or fir carrying over 45 per cent moisture) or for high overloads, use one square foot of grate for 35 sq. ft. of boiler heating surface.

These dimensions will serve for any desired overload by properly proportioning the draft equipment.

The fuel falling on to the grates through an overhead opening will cover an area roughly circular, or since we are dealing with rectangular grate areas, each fuel hole may be considered as serving a square. For best results the grates should therefore have dimensions that are multiples of 6, 7, 8, or 9 ft. The grates, however, should not be too deep to be readily cleaned with hand tools, a depth of 16 ft. being about the limit over which hand cleaning tools can be manipulated. Other things being equal, square grates lend themselves most readily to effective hog fuel furnace design.

A little reflection will disclose a well established relation between the quality of the fuel and the dimensions of the boiler being served. For example, assume a given load to be served by a boiler having 10,000 sq. ft. of heating surface, to be fired with an average grade of hog fuel. The grate surface therefore will be about 230 sq. ft. and with the ideal dimensions employed the furnace will be about 15 ft. by 15 ft. This establishes the most desirable boiler width to be 15 ft., although under certain conditions a dutch oven furnace may be two or three feet wider than the boiler. With this furnace, each of four fuel holes will serve an area of 7 ft. 6 in. x 7 ft. 6 in., which is within the practical limits.

This same boiler capacity might adequately be served with fuel oil in a boiler 10 ft. wide. This boiler would require, for the grade of hog fuel assumed above, a furnace 10 ft. wide by 23 ft. long, obviously impractical. It might be argued that with dry fuel the 10 ft. wide boiler could be served with a furnace 13 ft. wide by 15 ft. 3 in., since but 200 sq. ft. of grate is necessary. This, however, would necessitate each of four fuel holes serving an area 6 ft. 6 in. x 7 ft. 8 in., which is not an efficient area for best results. Better conditions would be obtained by increasing the boiler width to 12 ft. and employing a furnace 14 ft. by 14 ft. 6 in., affording a



Section through a 1667 hp. boiler designed for burning hog fuel. This boiler is operated by the Portland Electric Power Company, at Portland, Oregon.

better proportion. Thus the quality of fuel used has a direct bearing on the best dimensions of the boiler to be served.

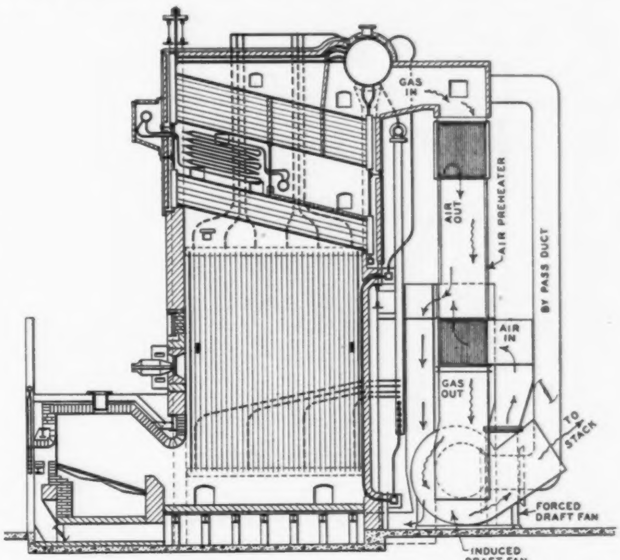
With the exit from the furnace restricted by the drop arch, the gases emerge into the combustion chamber at a high velocity. If the furnace, or stub, bridge wall is behind the drop arch, these gases are directed upward against the boiler tubes with a blast action that checks further combustion, and which sometimes causes localized overheating of the tubes, with consequent damage. If the rear bridge wall is built too close to the furnace throat, so that the flames impinge directly against it, and hog fuel is a long flame fuel, it has the effect of bottling up the furnace and the capacity is affected. Since the drop arch should be back of the stub bridge wall, deflecting the gases downward, the same restrictive effect is experienced, although in less degree, against the combustion chamber floor.

So much for the design of the furnace. The action of the fuel itself has very distinct characteristics. A hog fuel fire should not be disturbed by shaking or poking while burning, or it may be smothered. The combustion is distinctly a surface phenomenon, and when fresh fuel falls on to a burning pile the fire will flash up over the fresh fuel and often consume the surface while the interior of the layer is still green. The writer has seen a fire start at one corner of a 20,000 unit storage pile from a motor spark, flash over the entire surface of the pile faster than a man could run, and then practically go out, because there was no radiating surface above it to keep it burning. One half inch under the surface the fuel was virtually untouched. It is well known that sawdust is often used to smother electric fires. In other words, the stuff will burn, but it must have conditions just right, being perhaps more exacting in this respect than most other fuels.

A common source of danger, not always appreciated, is that where sander dust is blown directly into a hog fuel furnace from the blower system. In one case under the writer's observation, a failure of the fan motor stopped the fan. The blower ducts, being full of dust, generated a semi-explosive mixture and the fire from the furnace flashed back through the ducts nearly three hundred feet to the factory machine room, starting several fires. At another plant the furnaces were fed by fuel chutes from an overhead storage bin. Two men were sent into the bin to clean the dust off the trusses and conveyor supports. Some of the dust fell down through one of the open chutes to the furnace, the fire flashed back through this dust to the fuel bin and a near explosion resulted. Only the most strenuous efforts of a rescue crew prevented two fatalities. Danger from dry dust flash-over is not always appreciated in wood burning plants, but should be carefully guarded against.

Another peculiarity of this fuel is that forced draft does not do much good unless applied to the surface, literally impinging on it. Here again too much impingement will put the fire out. The force of the draft should stop just short of that sufficient to move the burning particles. This seems to be due to the fact that the vapors being distilled off the pile act as a cool blanket, preventing the air from reaching the incandescent surface of the fuel itself. Blowing the air with force scrubs this blanket off and permits contact between the air and the incandescent surface.

Forced draft under the fuel pile alone does not greatly aid combustion. The pile being cone shaped, it is obvious that its resistance to draft pressure is variable, and the thin corners and edges would "short circuit" the draft pressure just as would a hole in a coal bed.



Hog fuel furnace design applied to modern high pressure, high capacity boiler.

On the other hand induced draft is materially beneficial. It increases the velocity of the gases through the furnace, which is not undesirable if the arch is properly designed for it, and this by scrubbing off the fuel pile, promotes more rapid combustion. Then a certain amount of forced draft, just enough to keep the furnace pressure balanced, is a good thing.

There have been many attempts to devise mechanical stokers for hog fuel, and to evolve new and radical designs of furnaces, but only in a few exceptions has any of them approached the standard dutch-oven furnace in sustained excellence of results under all conditions with all classes of fuel. The correctness of this statement can be demonstrated by showing dutch-oven furnaces of the type described herein burning wood waste with over 40 per cent moisture and carrying sustained boiler ratings of over 400 per cent. These furnaces embody practically all the principles of good furnace design mentioned herein.

With the use of water-cooled walls becoming more widespread among hog fuel users, the radiating capacity of the gases of combustion becomes increasingly important. Since, as was pointed out previously, hog fuel gases have a particular aptitude for this method of heat transfer, it can be shown that water-walls with hog fuel will absorb a greater proportion of the total heat than is the case with other fuels. While the lower temperatures inherent in hog-fuel-fired installations dictate lower rates of heat transfer by radiation, the more favorable composition of the gases tend to compensate in a measure for the lower temperature, with the net result that water-cooled walls have proven of greater advantage than the low quality of the fuel would seem to justify. These walls should of course be confined to the

combustion chamber, and not be installed in the dutch-oven furnace.

While the use of air preheaters with hog fuel is entirely practical and economically justifiable, a very unexpected peculiarity has developed. Due to the high moisture content of the flue gases they have a high dew point; consequently, this moisture will sometimes condense on the plates at the cold end of the preheater. This condensation takes the form of a thin, creosote-like liquid, which may or may not entrap charcoal cinders carried through from the furnace. This deposit is not ordinarily troublesome, except where the cold end is quite appreciably below the dew point of the flue gases.

The preheater and gas ducts should be so designed as to eliminate pockets for the accumulation of cinders. If these deposits, heated by high ratings, are afterward brought in contact with air, a very hot and destructive combustion may result. In one high capacity installation, this phenomenon once resulted in the complete and rapid destruction of a large tubular preheater. The boiler in question was operated at a high rating for quite a period and then closed down for emergency repairs. Anxious to cool the setting as soon as possible, the draft fans were left operating and cold air admitted to the furnace. As soon as this air came in contact with hot cinders in the preheater, a hot fire flashed through it and entirely melted off the steel heating tubes in less than a minute. While this was an unusual occurrence, it emphasizes the necessity of eliminating cinder deposits from the gas passages, and the exclusion of air from any point where hot cinders may be deposited.

It is believed that the foregoing will demonstrate that hog fuel, normally looked on as a waste product meriting little attention, lends itself quite readily to the demands of modern steam generating equipment; that its characteristics, in spite of their contradictory nature, can be subjected to definitely practical rules which lose little of their usefulness by being based on empirical, rather than on mathematical data; and that its peculiarities can be turned to advantage to the end that a full measure of effective duty is obtained therefrom.

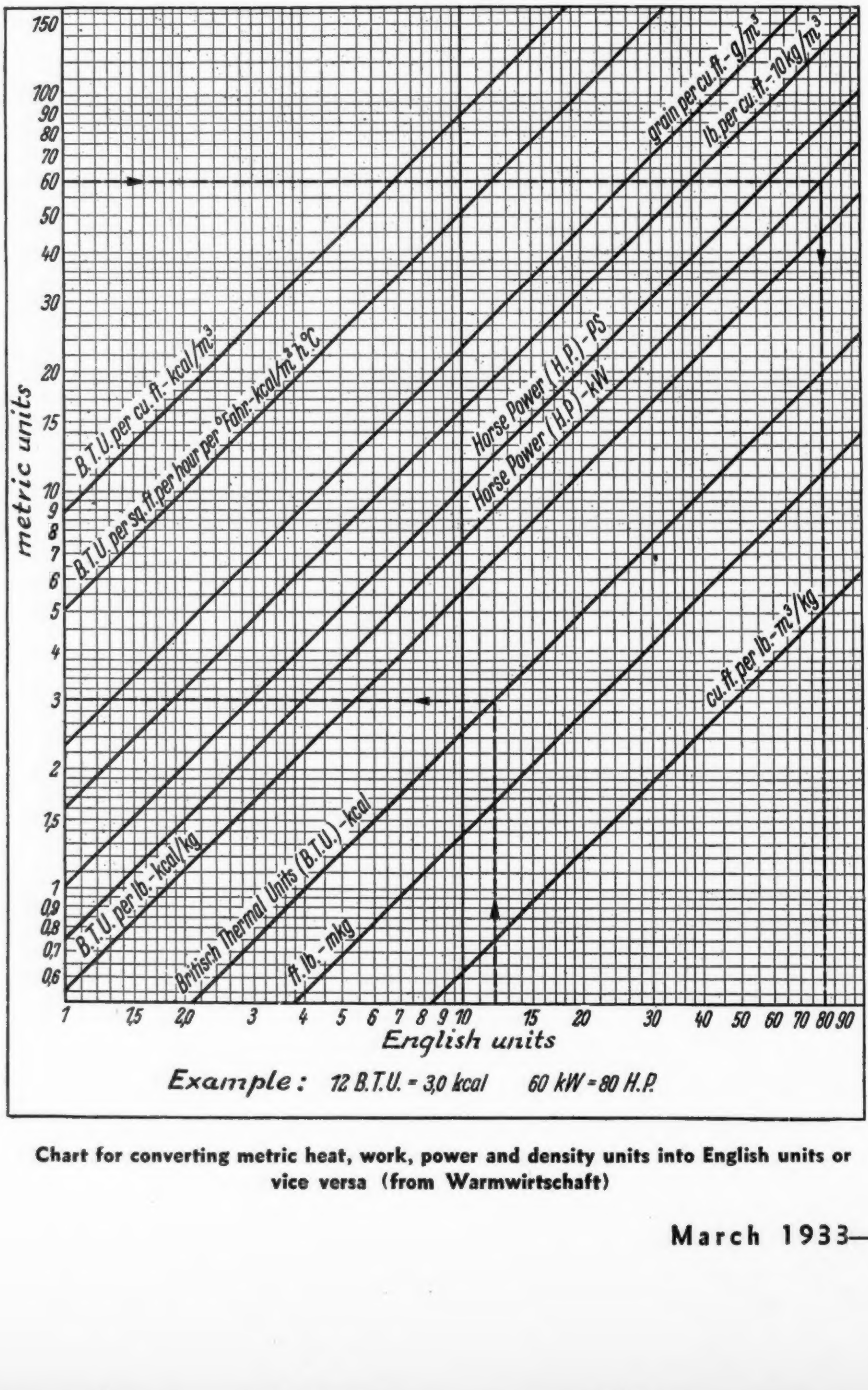
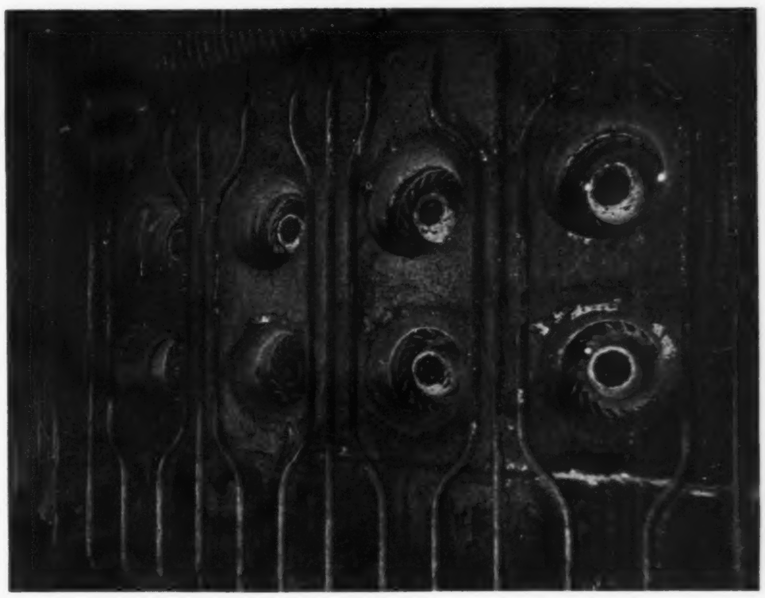


Chart for converting metric heat, work, power and density units into English units or vice versa (from Warmwirtschaft)

The Burlington Generating Station



View of pulverized coal burners showing connections for use of oil. Lower view shows burners from interior of furnace.

This article is an abstract of a paper presented by Marion Penn, General Superintendent of Generation, Public Service Electric and Gas Company of New Jersey and F. P. Fairchild, Power Engineer, United Engineers & Constructors Inc., at a meeting of the Power and Fuels Divisions, Metropolitan Section of the A.S.M.E., New York, February 6, 1933. It describes the new high-pressure boiler and turbine installation at the Burlington Generating Station of the Public Service Electric and Gas Company. This installation is of particular interest because of its advanced engineering features and more particularly because of the economies involved. These permitted the combination of old and new generating equipment in such a manner as to render a nearly obsolete station, used only for peak load capacity, as economical as any in the company's entire system.

THE first unit of the Burlington Generating Station of the Public Service Electric and Gas Company, of New Jersey was built in 1916. It was considered then to be modern and efficient. The second and third units were added in 1918 and 1922 and embodied improvements which had developed since the first unit was installed, bringing them up-to-date in equipment and efficiency.

Only sixteen years have passed since the first unit was installed and but ten since installation of the third. However, improvements that became available for later installations in other stations on the system rendered this plant all but obsolete by 1930. True, it served as peak load capacity and might be expected so to serve for some years to come. The normal expectation would be that equipment in the Burlington Generating Station would continue along to a respectable old age and finally be replaced completely. Recent developments and experience with high steam pressures and temperatures and the resulting standardization of materials and equipment made possible a complete change in the status of this generating equipment.

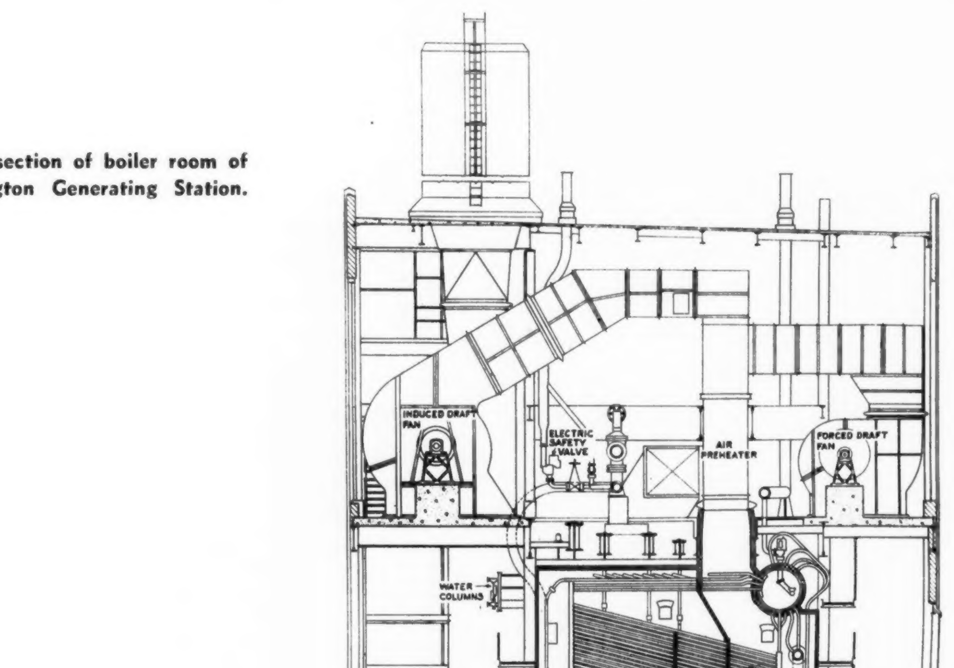
The installation of a modern high-pressure boiler and a turbine to receive the high-pressure steam and exhaust it at the pressure required by the old turbines, converted this station from a state of near obsolescence into a power producing unit equal in economy to any other in the entire system.

The old station contains 10 straight tube longitudinal drum boilers, designed to generate steam at 200 lb. per sq. in. gage pressure with 150 fahr. superheat. The boilers, fired by underfeed stokers operate at an average efficiency of about 70 per cent. The turbine generators have a capacity of 12,500 kva. each. The heat cycle was of the type almost universally used at the time the station was built and consisted of a single feedwater heater

which received exhaust steam from the station auxiliaries. A connection from the auxiliary exhaust header to one of the turbines permitted excess exhaust steam to be fed in and utilized or a deficiency to be made up by extracted steam from the turbine. The station heat rate was 22,000 to 25,000 B.t.u. per kw.-hr. which was a reasonably good economy at the time the station was designed and built.

In connection with the general study of increase in capacity of the various stations on the Public Service System, preliminary designs were made for the extension of Burlington Generating Station. The tentative plans contemplated the use of large turbine units, a pressure of 650 to 750 lb. and high superheat, 750 fahr. and higher. The selection of this pressure and temperature range was due to a desire to realize as high efficiency as possible without the added equipment and operating complication of reheat cycles. At the time the boilers were under consideration welded drum construction had not been approved by the A.S.M.E. code and the pressure of 730 lb. per sq. in. was decided upon as the maximum for riveted construction without going into special or expensive design. A study of superheater design developed the fact that 850 fahr. final temperature in conjunction with this pressure would be practical from a standpoint of design and materials and would assure a moisture content in the exhaust not too high for good practice. The arrangement of the first

Cross section of boiler room of Burlington Generating Station.



step of the new station development contemplated two turbines and four boilers of such capacity that three boilers could be run at sufficiently high ratings to carry the two turbines when one unit was out of service.

With such a high-pressure boiler installation the supply of steam to the old units through a high back-pressure turbine seemed logical. It was felt that maintenance schedules could be arranged for major repairs during off peak seasons, thus making the excess steam generating capacity available most of the year. The three old units could be operated on this excess capacity through the high back-pressure turbine. This program would provide 18,000 kw. of new capacity and bring the old turbines into efficient use without the expense of any additional boiler equipment.

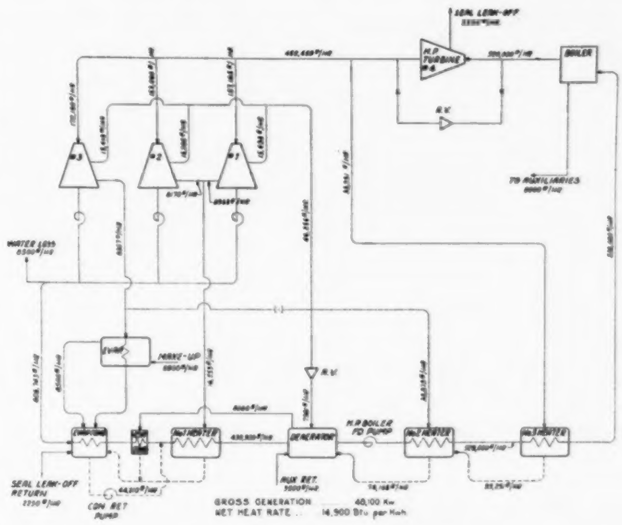
A full consideration of system power requirements at that time (1931) indicated that the complete development of the first one or two units of the new extension should be deferred to a later date. However, a capacity contract for the supply of energy in this district from a source outside the Public Service System was to expire at the end of 1931, and the provision of economical capacity in the Burlington Generating Station would obviate the necessity of renewing this contract. Studies indicated that the installation of one high-pressure boiler of the size and type to be used in the future extension of the station and a high back-pressure turbine would, in view of the contract cancellation, be a profitable procedure. Accordingly, the addition of steam generating equipment capable of producing 525,000 lb. per hr. continuously and an 18,000 kw. turbine-generator was decided upon.

A heat balance arrangement was devised which took the fullest practical advantage of the possibilities of the existing equipment. The arrangement of the heat cycle includes a three-stage regenerative feed heating system and an evaporator for make-up. The low-pressure heater is supplied with steam bled from the two newest of the old turbines. The intermediate and deaerating heaters are supplied with steam bled into a common header from all three of the old turbines. The high-pressure heater receives its steam from the exhaust of the high-pressure unit. The oldest of the three original units is somewhat different in design from the other two and as a consequence the pressure at its lower bleed point does not correspond to that of the other two. Because of this condition interconnection of the lower bleed points of the three units was not practical. The lower bleed point on the old machine was therefore used to extract steam for a make-up evaporator. For the loads at which the station was expected to operate, such a cycle indicated an expected heat rate of about 15,000 B.t.u. per kw.-hr. delivered to the outgoing lines. This represented an improvement over the old station of 32 to 40 per cent. In addition to the saving in fuel, a material saving in operating labor and maintenance costs was expected as a result of shutting down the old boiler plant.

The results attained in actual operation fully bear out predictions as to performance.

Pulverized fuel firing was selected partly because the designers felt that units of such size are more suited to pulverized fuel firing than to stokers and partly because of the flexibility of the pulverized fuel furnace in the matter of burning fuels of widely varying characteristics.

In considering type of boiler, the straight tube arrangement offer the least expensive design for the pressure decided upon. To have adopted the bent tube



Operating heat balance.

type would have meant very special design or the use of (at that time) forged drums. In order to provide advantageous furnace dimensions and to assure minimum cost of the boiler evaporating surface, 26 ft. tubes were used. Looking toward simplicity and the desire to keep the number of kinds of equipment in the plant at a minimum, a high boiler with an air preheater was selected rather than a low boiler with economizer and air heater. An overall boiler efficiency of about 85 per cent was used as basis of design.

The boiler is of the inclined straight tube cross drum type, and contains 1120—3½ in. No. 4 gage seamless tubes in the main tube banks. The total heating surface is 30,300 sq. ft. The boiler drum is of 2⅝ in. plate, is 60 in. in dia. and the shell 39 ft. long.

The boiler furnace is of the dry bottom type and ash is removed by a hydraulic sluicing system.

The furnace has water-walls on the two sides and the rear and on the part of the front wall above the burners. The water-walls are made up of 3½ in. dia. fin tubes and the bottom screen is of 3½ in. plain tubes. The boiler is steel cased and insulated with the casing so placed that all water-wall and bottom screen downcomers and connections from drum to superheater headers are within the casing. This arrangement avoids the necessity of insulating all these pipes, improves the appearance of the unit as a whole, and makes it cleaner due to the absence of a multiplicity of external pipes to collect dust.

The superheater is of the multi-loop bare-tube type and contains approximately 9,200 sq. ft. of effective surface made up of 2 in. o.d. tubes with a wall thickness of 0.165 in.

The design and arrangement of this superheater was arrived at after consideration of various types. A straight parallel-flow design would not give the desired final steam temperature. A combination part parallel and part counter current design was considered. This would give a satisfactory superheat curve but was expensive and complicated in design. A straight counter-

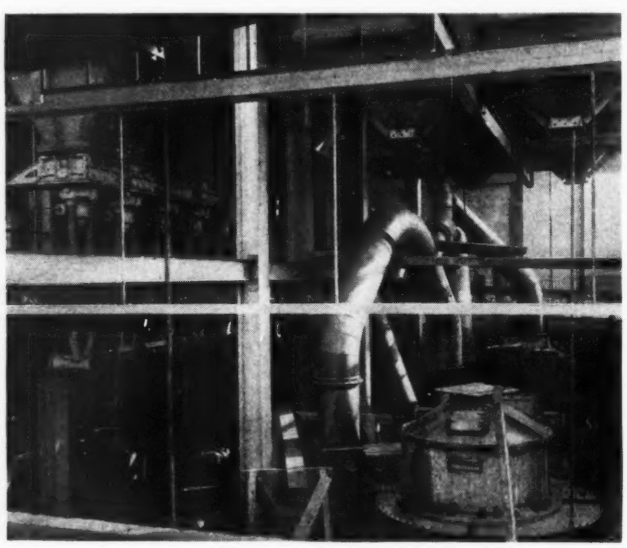
current design was finally selected as combining economy of cost, simplicity of design and satisfactory performance characteristics.

Each superheater element consists of six and one-half return bends, the upper five and one-half of which are ordinary mild steel, and the lower of chrome vanadium steel. This arrangement gives thirteen passes for the steam, two in alloy steel tubes and eleven in ordinary steel. It might have been desirable to make a greater proportion of the tubes of alloy steel, but the maximum one-piece length of alloy tubing obtainable was only sufficient for one loop. No satisfactory method for welding two pieces of alloy steel was known, though it could satisfactorily be welded to the ordinary steel. Recently the alloy steel has been made in longer pieces and replacement elements have a loop and a half or three passes of this material. However, nothing has occurred in operation that would indicate that the additional pass of alloy steel was essential.

The upper or inlet superheater header is connected to the steam drum of the boiler by twenty 4-in. tubes. The superheater is designed to heat the steam to a total temperature of 860 fahr. when steam at 700 lb. per sq. in. gage is delivered to it at the rate of 525,000 lb. per hr.

In the selection of the pulverized fuel system the designers have endeavored to combine as far as possible the advantage of the storage system with its close control and greater flexibility with the compactness and straight forwardness of the direct system. The interposition of bin and feeders between mills and burners also insures continuity of rating on the boiler during temporary stoppage of the pulverizing equipment. As will be noted from inspection of the boiler room cross section, the raw coal bunker, mills, primary air fans, separators, pulverized fuel bin and feeders are compactly arranged in a low section of the building. The burner pipes extend from the feeders up to the burners. The result is a maximum of light and air to the boiler firing aisle.

Coal is supplied to the raw coal bunker by an extension of the conveyor system from the old station. Two vertical coal pulverizers are located directly below the



Construction view showing pulverizing mills. Feeders can be seen in the upper left corner.

bunker and receive crushed coal through two chutes. Each pulverizing mill has a capacity of 44,000 lb. per hr. when handling coal containing 4 per cent moisture, and with air fed at 400 fahr. This is sufficient to produce 480,000 lb. per hr. with one mill in operation. The pulverized fuel bin will hold about 5 hours' supply.

The boiler furnace is equipped with eight 30-in. horizontal pulverized coal burners. Coal is fed to these burners by eight rotating disc feeders.

The combustion control system is of the air actuated type and varies the rate of coal and air supply and draft in accordance with changes of pressure in the main steam header.

The forced and induced draft fans are motor driven. Each fan is provided with two constant speed induction motors, one at each end of the fan shaft. One of the motors is of size and speed suitable for operation of the fan at maximum load while the other smaller motor is of size and speed suitable for operation up to about 2/3 maximum load. Control of delivery is accomplished by regulation of inlet vanes on the fans.

The forced draft fans deliver air through a plate-type air preheater to the burners, mills and feeders. At 525,000 lb. per hr. actual evaporation, the air is preheated to a temperature of 498 fahr. and the flue gas temperature is thereby reduced to 456 fahr.

The high-pressure turbine is a single cylinder, non-condensing straight reaction unit designed for a throttle pressure of 650 lb. per sq. in. and a total steam temperature up to 875 fahr. In view of the fact that only one high pressure steam generating unit was to be installed it was necessary to design the steam system in connection with the three existing turbines so that they could be operated on the old boilers when the high-pressure boiler is down for repairs. Some consideration was given a scheme of carrying a constant back pressure on the new high-pressure turbine so that no changes would have to be made on the old low-pressure units, but this was discarded in favor of varying intermediate pressure in consideration of the better overall economy resulting with such a scheme. The only change made on the three turbines was the substitution of new nozzles for the inlet steam and increasing clearances.

Under normal operation the high-pressure unit and the three low-pressure units run as a compound turbine, control being entirely by the high-pressure turbine governor. The generators of the four elements are tied together electrically and the governors on the three low-pressure units are wide open. With this arrangement the exhaust pressure from the high pressure unit and consequently the inlet pressure to low pressure machines varies with the load.

The auxiliaries in the old station were mainly steam driven and the question arose as to the economical disposition of the exhaust from these auxiliaries with the regenerative cycle proposed for the new installation. Studies made to determine the economic value of substituting motor drives for the existing steam drives indicated a fuel saving sufficient to make such a change profitable. Most of the station auxiliaries were therefore motorized.

The four generators are connected to one main 13.2 kv. bus. The customary auxiliary bus is provided for starting and to permit working on switches with gener-

ators in operation. The bus structure, switches, etc., in the original installation were not adequate for the new conditions and a new bus and switch cell structure was constructed within the existing building. The old switches were replaced with ones of higher interrupting capacity. A panel was added to the existing control board to take care of the new generator.

The station is connected through the Public Service Electric and Gas Company's substation at Camden to the transmission system of the Philadelphia Electric Company and through a switching station at Trenton to the transmission line of the Public Service Electric and Gas Company and also to that of the Philadelphia Electric Company.

Excitation of the old units was by separate turbine-driven 125 volt generators. The elimination of steam auxiliaries previously discussed included these exciters and they were replaced with new shaft end generators on the main generators. The new unit is provided with a 250 volt shaft end exciter and a motor-driven emergency exciter which will be connected to the emergency exciter bus of the future extensions.

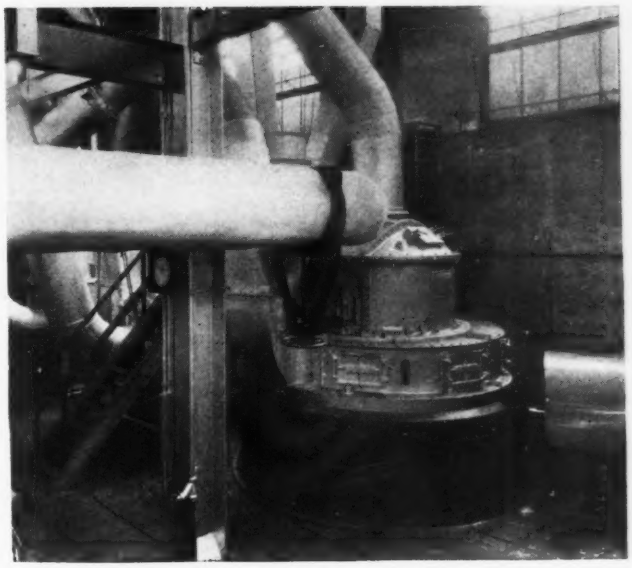
Two station service feeders are provided, one for the auxiliaries in the old station provided with 13.2 kv./440 volt transformer bank and the other for the new boiler plant substation provided with 13.2/2.3 kv. transformer bank. The substation for the new boiler plant and future extensions to the turbine plant is located beneath the new boiler plant and is designed to provide for extension to take care of additions as they are made. This location is close to the load center and permits a simple and direct arrangement of feeders to the various motors.

One of the interesting features of this installation is the fact that, as far as it was practical to do so, pipe joints were welded. Flanged joints were used only for connections to large valves and where joints must be broken frequently.

This is the first high pressure power plant in which welding for pipe joints was used throughout to such a large extent. As many welded sections as possible were made in the fabricator's shop. These were made by the electric arc weld process using coated rod. The extent to which shop welding could be used was of course limited by the size of pipe sections that could be shipped to the job. Field welds were made by the oxyacetylene process and all high pressure pipe welds locally annealed after completion.

Special precautions were taken in securing competent and expert welders to do the work, as the perfection of a welded joint depends almost wholly upon the ability and carefulness with which the work is executed. The high pressure steam header is 18 in. in dia., and 1½ in. thick and the completion of a weld in this pipe required 22 hours continuous work. Two welders were qualified for this heavy work and they both had to work continuously from the start to completion of one of these large welds. Normal fatigue would tend to make even the best men less careful toward the end of such a long period. To insure perfect work it is therefore necessary that the men selected be thoroughly conscientious and reliable.

The welds were V type, and on all pipe for 200 lb. pressure and over, longitudinal reinforcing straps were welded on after completion of the joint weld. These



One of the 15 ton pulverizing mills.

straps were bent so that their two ends could be welded to the pipe leaving the part over the weld bulged up and not in contact with the pipe weld.

Valves in the larger lines were flanged but many of the smaller valves were welded directly to the pipe.

The annealing of the large pipe welds presented a problem for which no equipment was available. A portable box was made up of steel plate lined with asbestos which could be placed over the joint. With the box in place the joint was heated to the desired temperature with oil torches after which the box was packed tight with asbestos and the pipe permitted to cool.

The use of field welding in power plant piping was something of a new departure when this plant was buiit and methods and details had to be developed for the job. For this reason there was probably little if any actual saving in cost as compared with that of flanged joints. However, experience in this case indicates that field welding can be used in high-pressure power plant piping construction at no greater cost and possibly for less than the cost of a proper flanged installation. All field welds were tested after completion by applying hydrostatic pressure of 1500 lb. per sq. in. and hammering with a heavy sledge.

There has been no failure of welds experienced to date.

Shortly after the new installation was put in service the price of fuel oil receded to a low level. Studies indicated that its use in place of coal would result in a material saving in fuel cost even after deducting fixed charges which included a high amortization on the installation cost.

A fuel oil storage, handling and burning system was installed comprising a 20,000 barrel tank located just west of the station near the river, an unloading wharf and the necessary pumping, heating and burning equipment.

The oil burners are inserted through the center of the pulverized fuel burners and their installation required practically no changes in the original burners. A change from oil to coal or vice versa can be made easily and with virtually no delay.

The boiler and turbine were put in service February

17, 1932. The outages due to boiler trouble up to December 24, 1932, have totaled 917 hours or a total availability for the boiler of about 88 per cent. The outages due to turbine trouble some of which were coincident with boiler outages totaled up to December 15, about 1281 hours, giving a total availability of about 82 per cent. None of the outages can definitely be attributed to the pressure and temperature or to the system. They were for the most part of the character usually encountered during the early operating period of new equipment.

The boiler operated continuously from August 13 to December 24 and during this period produced 1,373 million lb. of steam. This is an average of about 429,000 lb. per hr.

Data of Principal Equipment*

Boiler

Walsh and Weidner Sectional Header Boiler. Boiler heating surface 30,300 sq. ft. Design pressure 730 lb. Drum 60 in. dia., 39 ft. 0 in. long. Tubes 3½ in. dia., 26 ft. 0 in. long. Combustion Engineering Corporation.

Superheater

Elesco, convection interdeck type. Heating surface 10,650 sq. ft. The Superheater Company.

Boiler accessories

Soot blowers—26 revolving type automatic valve-in-head, (2 stationary)—Diamond Power Specialty Corp.
Water Columns—Diamond Power Specialty Corp. Pressure Gage and Safety Valves—Consolidated Ashcroft Hancock Co., Inc. Stop Valves and Check Valves—The Lunkenheimer Co. Blow-off Valves—Cochrane Corporation.

Furnace water walls

Fin type tubes 3½ in. O.D. on rear and side walls. Plain tubes on front walls and plain tube water screen. Total heating surface 4,816 sq. ft. Combustion Engineering Corporation.

Pulverized coal burners

8 Type R horizontal burners. Combustion Engineering Corporation.

Pulverizing mills

2 Raymond roller mills with mill exhausters and collectors. Capacity 15 tons per hr. Combustion Engineering Corporation.

Feeders

8 Type R rotating disc type. Combustion Engineering Corporation.

Air preheater

Plate type. Heating surface 41,800 sq. ft. Combustion Engineering Corporation.

Fuel oil equipment

8 burners to be used in pulverized coal burners—Engineer Company.
3 Pumps—3½ in.—30,000 lb. per hr. each—Quinby Pump Co.
2 Heaters—30,000 lb. oil per hr. each from 100 to 250 fahr. with steam 200 lb. per sq. in.—Ross Heater & Mfg. Co.

Forced draft fans

1 turbovane—Design 5—168,000 c.f.m. at 100 fahr.—10 in. S.P. with movable vane control. B. F. Sturtevant Co.

Induced draft fan

1 turbovane—335,000 c.f.m.—13 in. S.P. B. F. Sturtevant Co.

Combustion control system

Hagan Corporation.

Ash Handling System

A-S-H Hydrojet. Allen-Sherman-Hoff Co.

*Not included in original paper. Published here through courtesy of the Public Service Electric and Gas Company of New Jersey.

Boiler Feed Pumps

3—750,000 lb. per hr. at 220 fahr. again 850 lb. per sq. in. Two motor driven and one turbine driven. Ingersoll-Rand Company.

Boiler feed pump turbine

1—1250 b.h.p. 1800 r.p.m. steam 730 lb. per sq. in. 850 fahr. temperature to 5 lb. back pressure. B. F. Sturtevant Co.

Feed water heaters

1—2280 sq. ft. to heat 506,000 lb. water per hr. 59 to 200 fahr. with steam at 13.3 lb. per sq. in. abs. at 100 lb. per sq. in. water pressure.
1—2500 sq. ft. to heat 608,000 lb. water per hr. 200 to 315 fahr. with steam at 94.5 lb. per sq. in. abs. at 900 lb. per sq. in. water pressure.
1—2700 sq. ft. to heat 608,000 lb. water per hr. 315 to 384.5 fahr. with steam at 220 lb. per sq. in. abs. at 900 lb. per sq. in. water pressure. Ross Heater & Mfg. Company.
1 Deaerating Heater with vent condenser to handle 608,000 lb. water per hr. Cochrane Corporation.

Feed water regulators

2 Copes Combination boiler water level control and differential pressure regulator valves with thermostatic control. Kissick-Fenno Company.

Evaporator and evaporator condenser

1 Horizontal tube—12,000 lb. vapor per hr. at 4.5 lb. per sq. in. abs. from water at 60 fahr. using steam at 17 lb. per sq. in. abs. Distillate to contain not more than 0.5 grs. per gal. total solids. Foster-Wheeler Corp.

Turbo-generator

1—22,500 kva. 3600 r.p.m., 3 phase, 60 cycle, 13,200 volts non-condensing high back pressure. Throttle pressure 650 lb. per sq. in. gage and 825 fahr. total temperature. Exhaust pressure maximum 205 lb. per sq. in. gage. Westinghouse Electric & Mfg. Company.

Generator air cooler

Westinghouse Electric & Mfg. Company.

House Service Pumps

3—DeLaval 1000 g.p.m. against 200 ft. discharge head 1760 r.p.m. Two for motor drive, one for turbine drive. Turbine Equipment Company.

House service pump turbine drive

1—75 b.h.p. 1800 r.p.m. for 730 lb. per sq. in. steam pressure and 850 fahr. total temperature to exhaust against 5 lb. per sq. in. gage. B. F. Sturtevant Co.

Large motor drives

Crocker-Wheeler Electric Manufacturing Company.

Springs for pipe supports

Railway Steel Spring Company.

Heat treated studs

Bethlehem Steel Company.

Vacuum cleaning system

The Spencer Turbine Company.

The Westinghouse Electric and Manufacturing Company announces the appointment of C. H. Champlain as General Works Manager of the company. In his new position Mr. Champlain will supervise the management and operation of the nation-wide plants of the Westinghouse Company. Mr. Champlain has been with Westinghouse for many years, his first position being that of machinist.

At the time of his appointment Mr. Champlain was Works Manager of the East Pittsburgh Works. T. I. Phillips has now been appointed to that position. Mr. Phillips, formerly Works Manager of the Nuttall Plant, in addition to new duties of factory management and operations, remains in charge of the Nuttall Plant in a supervisory capacity.

Patents*

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PART VIII

This article points out the necessity for properly marking patented devices. It also explains the remedies for correcting errors in a patent by Certificate of Correction, by Disclaimer, and by Reissue. . . . . Mr. Ramsey answers questions which frequently arise as to the effect of a patent in connection with an infringement suit based on some prior patent and as to why a patent is infringed by one who makes the patented article for his personal use. He also explains why the Government does not enforce patents, and why the Government cannot guarantee the validity of patents.

Marking

When the patent is granted and the article patented is being manufactured, the manufacturer should mark the patented article by affixing thereon the word "Patent" together with the number of the patent. When the character of the article is such that the marking cannot be applied to the article in a satisfactory way, then the marking may be applied to the package wherein one or more of the articles is enclosed.

Where the patentee fails to so mark the patented article, the law provides that no "damages" shall be recovered in an infringement suit except upon proof that the defendant was duly notified of the infringement and continued after such notice to make or use or sell the article so patented. The marking must be strictly in accordance with the law, otherwise it is of no force and effect. There is no objection to adding other words to the marking providing the article is clearly marked with the word "Patent" and the number of the patent. It has been held that where articles were not marked and no actual notice of infringement was proven prior to the starting of the suit, that neither costs of the suit nor an accounting would be granted by the Court. An injunction, however, may be issued against the defendant to preclude continuation of the infringement. It has been held that where the patented feature relates to a part only of a complicatd machine or a large device such as a railway car that the marking should be applied to the actual device which is patented. For example, if the patented feature in a railway car is the drawbar construction, then some place on the drawbar construction, the marking should be applied. It has also been held that where the marking cannot be read, that such an attempt to mark is insufficient. This sometimes happens where a die is used to impress the marking on articles manufactured and the die becomes so worn that it is not possible to distinguish the lettering or the numbering. Under these conditions, recovery of damages is not allowed back of the date of actual notice. While the statute specifically specifies "no damages shall be recovered," the law has been interpreted by the Courts as including both profits and damages. It has been held also that mere incidental notice of a patent to the defendant is not sufficient, that is, if the defendant knew that a patent was in existence, but had not been specifically charged with infringement, the mere knowledge of the patent is not considered in the law as definite notice. In a case where a patentee does not manufacture and consequently cannot mark articles under the patent as being patented, it is necessary for the patentee to give infringers notice in order to collect for profits or damages, except such as arise after bringing a suit for infringement. No profits or damages in such case ordinarily will be allowed prior to actual notice. However, the authorities are in conflict on this particular point. Where the patented device covers a process, articles made under the process should not be marked as "patented" because the patent is not directed to the article but to the method or process by which the article is manufactured. Where a patented device is normally concealed when in use, such as reenforcement for concrete flooring, the Court will take judicial cognizance of the inability to mark the article patented. Under these conditions, however, it may be advisable to attach a tag to the article, when it is sold, carrying the proper marking. The marking of a few articles which are sold without marking all the articles that are sold has been held to be no marking at all. The marking of an article "Patent Applied For" or "Patent Pending" is of no value when the patent is issued in that it is not a compliance with the statute.

From the foregoing, it will appear that a proper marking of articles being sold under the patent is of substantial importance because a recovery which might otherwise be made may be entirely lost. The profits which otherwise may have been recovered may be extremely large prior to the date of actual notice, but if there is no marking no recovery can be made prior to the date when the defendant was actually and properly notified of infringement.

The law also provides that anyone who marks an unpatented article with the word "Patented" or any word to this effect for the purpose of deceiving the public; or who marks upon any article, without the consent of the patentee, the name or any imitation of the name of the person who has obtained a patent; or who attempts to counterfeit or imitate the mark or device of the patentee, without the patentee's consent; shall be liable to a penalty of not less than $100.00 with costs for each such offense. This statute is in the nature of a criminal statute and requires proof which must be sufficiently strong to convict under the criminal laws. This statute does not apply to one who has obtained a patent and who marks his articles patented with the honest belief that they come within the patent, whereas as a matter of law, such articles are not covered by the patent. In a case of this kind, the question of intent of the defendant must be considered. While the statute is specific to the word "person," the Courts have ruled that a corporation comes within the meaning of the statute and is liable for false marking. The Courts have also held that while a plaintiff may be guilty of false marking, this fact is not a defense in an infringement suit. Where a suit is brought to punish a defendant for false marking, one-half of the penalty imposed, should the defendant be found guilty, goes to the person who institutes the suit and the other half goes to the United States. This law prohibiting false marking is a commendatory law because as we have pointed out a patent grants the patentee a monopoly and if there were no penalty against false marking, unscrupulous parties might pretend that their articles were patented and thereby unjustly and illegally restrict the manufacturing which otherwise would be free and open to the public.

Correction of a Patent

When a patent has been signed and sealed by the proper authorities of the Patent Office and delivered by the patentee, it is beyond the jurisdiction of the Patent Office and cannot be recalled. It may, however, be surrendered to the Patent Office for correction. The law provides three ways in which errors may be remedied. First, errors made by the Patent Office are corrected by returning the patent to the Patent Office for the attachment of a "Certificate of Correction" issued by the Patent Office. Second, where the inventor believes that he has included within the scope of his patent more than he is entitled to cover in his patent as an original invention, he may "disclaim" the matter which should not have been included originally. Third, should the patentee think the patent is inadequate to protect the real invention and he does not discover that the real invention has not been adequately covered in the patent until after the patent has been actually issued, then the error may be corrected by re-issue.

Certificate of Correction

When the patent is being prepared for issue, the file wrapper enclosing the specification and claims is sent to the Public Printing Office to be set up in type. These files may contain hundreds of changes comprising substitute phrases, changes in wording of claims, corrections of spelling, and other amendatory matter. The changes are all indicated as interlineations in the original specification and where a patent has been pending some years and many amendments have been entered, it is a difficult task to get all of these amendments in their proper place when the case is finally set up in type. It is not unusual that errors occur. Errors by the Public Printer are considered as the fault of the Patent Office.

The patent drawings are lithographs of the original drawings, and occasionally an error occurs in the lithograph drawings, although such errors are not as frequent as in the printed copy of the specification and claims because amendments to the drawings are relatively few as compared to amendments to the specification and claims.

Where the patentee discovers that the printed patent does not agree with the record, the original patent should be returned to the Patent Office with a request for the issuance of a Certificate of Correction. This certificate is signed by the Commissioner or by an Assistant authorized under the law to act for him, and is sealed with the seal of the Patent Office. The certificate states the facts as to the original records and that the patent is to be read in the corrected form. This certificate is attached to the original patent and the law provides:

> "Such certificate shall thereafter be considered as a part of the original, and every patent together with such certificate, shall have the same effect and operation in law on the trial of all actions for causes thereafter arising as if the same had been originally issued in such corrected form."

Attention is directed to the word "thereafter" which appears twice in the statute. From the inclusion of this word in the statute, it seems clear that the intent of the statute is that where a serious error occurs in a patent which would change or restrict the interpretation of the patent as to infringement, a Certification of Correction must be made before the patent is fully effective. This correction, in view of the word "thereafter," would have to be a part of the patent before any charge of infringement could be enforced. In view of this fact, it becomes important that the patent should be promptly checked against the duplicate record in the attorney's office immediately after the patent is received, otherwise, there is danger of loss of valuable rights if any serious error has been made. If an error in the patent appeared to give the patentee broader claims than the record showed he was entitled to have, and that these erroneous broad claims were due to an error in printing, it is extremely doubtful if such claims could be sustained as valid.

The grant of the patent states:

> "WHEREAS John Doe, of New York City, New York, presented to the Commissioner of Patents a petition praying for grant of Letters Patent for an alleged new and useful improvement in LOCOMOTIVES, a description of which invention is contained in the specification of which a copy is hereunto annexed and made a part hereof,"

The printed specification is "the copy" but the grant is based on "the specification," namely, the original record which is in the archives of the Patent Office. The drawings and claims are in the law considered a part of the specification, so, therefore, it is the full

record in the Patent Office which is controlling. Consequently, the Patent Office has full authority to state what the true record is, and this is the foundation upon which the patent rests. The grant of the patent itself is a deed and is not a copy of any record in the Patent Office, but, is made up in accordance with the records. A question in the past has arisen as to whether an error in the grant could be corrected by a Certification of Correction, since prior to 1925, there was no authority in the law to issue Certificates of Correction. On that date, a law was passed authorizing the Commissioner to issue Certificates of Correction stating what the true records were, and this law is sufficiently broad to cover any part of the patent including the grant itself. There is no charge by the Patent Office for issuance of a "Certificate of Correction."

Disclaimer

If the printed copy of the patent is a true copy of the original records in the Patent Office, but the inventor finds that he himself has made a mistake, then the Patent Office will not issue a Certificate of Correction because such a proceeding does not come under the type of errors which can be laid at the door step of the Patent Office. If the error resides in the granting of a claim which the patentee later finds to be clearly invalid or of the inclusion in the specification of features set forth as part of his invention, which features were old in the art or which he did not invent, then the patentee's remedy is by way of "disclaimer." A disclaimer is intended to limit the scope of the patent and not to enlarge it. A disclaimer may be made to the descriptive portion of the specification or drawings or it may be made as to the claims. The disclaimer as to the claims may disclaim an entire claim or it may restrict the elements set forth in any claim so that it has a more narrow interpretation than the language of the claim itself would indicate. A disclaimer may be filed by the patentee, his heirs, or assigns whether the owner of the whole or a sectional interest therein. Under these conditions, where the owner of only a part of the interest in a patent disclaims, but the owners of the remaining title do not disclaim, the patent has a double effect, that is, the disclaimer is operative only as to those who join in the disclaimer, but is not effective against others who do not join in the disclaimer. The disclaimer must be in writing, must be accompanied by a proper fee, and must be attested by one or more witnesses and be recorded in the Patent Office. It shall thereafter be considered as a part of the original specification of the patent. Where a suit is brought upon a patent, and a judgment or decree rendered in part for plaintiff and in part for the defendant, to the extent that the plaintiff is not the original and first inventor of a material or substantial part of the thing patented, no costs shall be recovered. This means that where a number of claims are sued upon and certain of the claims are held to be valid and others of the claims are held to be invalid, then no costs shall be recovered unless a proper disclaimer was recorded in the Patent Office before the suit was brought.

Prior to the statute permitting disclaimers, it had been held that where a part of the patent was invalid, no recovery could be obtained upon the remaining part of the patent, and it was to correct this hardship in the law that the disclaimer statute was enacted. The disclaimer statute, however, specifies that no patentee shall be entitled to the benefits of the disclaimer statute if he has unreasonably neglected to enter a disclaimer. This may mean that where the patentee was aware of the error in the patent and he did not act within a reasonable time to advise the public of this error but continued to hold out his patent as though it were entirely operative, that under these conditions, he may not be able to enforce any part of his patent providing the unreasonable neglect or delay can be established. The prompt entering of a disclaimer does not prevent the full operation for the full term of the patent, both before and after the disclaimer, as being effective against infringers of the proper portion of the patent which had not been disclaimed; so, therefore, it is desirable that a disclaimer shall be entered with reasonable promptness when the trouble is discovered.

It has been held, where an applicant in the Patent Office gave up narrow claims and then obtained broad claims which later were found to be of questionable validity, that the patentee could not by disclaimer give up the broad claims and return to the narrow claims which he had given up in the Patent Office. Under these conditions, a disclaimer would not be operative because the Court held that claims once abandoned could not be recaptured by way of disclaimer. It has been contended that the filing of a disclaimer constitutes an admission that the patent without the disclaimer would be invalid, but the Courts have held this is not the case. The only purpose of the disclaimer is to cure ambiguities which should be taken care of to properly define patentee's true invention. The disclaimer is operative not so much to radically change the specification and claims as it is to restrict the same without substantial change in character of the patent. In other words, a patent issued for an article of manufacture could not by disclaimer be changed into a process patent even though the specification fully disclosed the process by which the article was made. Additional claims cannot be added by disclaimer since this would enlarge rather than restrict the patent.

Reissue

Reissue constitutes the third way in which a patent may be corrected. The term "reissue" is sometimes erroneously understood as being a proceeding by which the life of a patent may be extended. Patents issue for seventeen years and can be extended only by a special act of Congress. The chances of having a special act passed by Congress are not very good because such an act would usually benefit only a small group of individuals and such a law is not regarded with particular favor by Congress. Extensions of patents by Congress have been made in the past but none have been extended in recent years, although attempts have been recently made for such special legislation.

The law of reissues provides that whenever any patent is wholly or partly inoperative or invalid by reason of a defective or insufficient specification, or by reason of the patentee claiming as his invention or discovery more than he had a right to claim as new, if the error has arisen by inadvertence, accident, or mistake, without any fraudulent or deceptive intention, the Com-

missioner shall, on the surrender of such patent and the payment of the duty required by law, cause a patent for the same invention, and in accordance with the corrected specification, to be reissued to the patentee or his assigns or legal representatives, for the unexpired part of the original patent.

The law as to reissues includes practically the same ground as is included by the disclaimer statute, but the law as to reissues goes much further. Where a patent disclosure is inoperative, it is doubtful if proper correction could be made by disclaimer, but this defect is specifically provided for in the authority of the Patent Office to grant reissues; therefore, a reissue would be the proper way to cure this defect. Furthermore, a disclaimer is not intended for the purpose of increasing or extending the scope of a patent, whereas if a reissue is promptly filed, the patentee may submit additional claims to claim in his reissue the invention more broadly than it was claimed in his original patent. Ordinarily, broadened claims will not be allowed in a reissue filed more than two years after the grant of the original patent, but, if the reissue is made within two years from the grant of the original patent, claims may be obtained as broad as the art will allow.

It will be observed that the law requires the patentee to surrender his original patent. Where the patent is surrendered, its life prior to the grant of the reissue is cancelled, that is, no remedy for infringements prior to the grant of the reissue can be enforced, except as to claims in the original patent. Under the law prior to 1928, the surrender of a patent granted an immunity bath to all infringers prior to the date of reissue. In the year 1928, the reissue statute was amended so that if the reissue patent retained claims of the original patent, then no immunity bath was granted so far as the original claims were concerned, but so far as new claims were contained only in the reissue, no infringement relating to these new claims could be charged except after the reissue date.

Where the original patent in a single document disclosed several different inventions, the Commissioner may in his discretion upon a reissue of this original patent grant several reissue patents for separate and distinct features of the thing originally patented. That is, if the original patent claimed only an article of manufacture, but disclosed a method, reissues in some cases may be obtained, for both the article and the method. Under these conditions, a separate fee is required for each reissue patent.

In reissuing a patent, no new matter may be introduced, although any feature shown or disclosed in the specification or drawings may be more fully and clearly described or the description thereof amplified. When an application for reissue of a patent is filed in the Patent Office, the application is treated as though it were an original application and is subjected to revision and restriction in exactly the same way as an ordinary case. The reissue application must be accompanied by the original patent or a certified copy thereof. This original patent, however, is not surrendered until the reissue is actually granted. So, therefore, if a reissue application is filed, but for some reason the patentee may decide to abandon the reissue application, then the original patent is returned to him in its original form and it stands just as though no attempt had been made to reissue it.

In connection with reissued patents, a peculiar situation may arise known as "intervening rights." The inventor is presumed to have claimed all that belongs to him in the original patent and as to that which he did not claim, providing it was new, he dedicated it to the public. The public has a right to rely upon the patentee's claims as defining the scope of the monopoly which he has staked out as being his own. Therefore, if the claims of the original patent are narrow in scope and some member of the public decides he can build a machine which does not infringe these claims and proceeds to invest money, time, and effort in exploiting the enterprise, he has done that which he had a right to do. Later he may be confronted by a reissue patent with claims sufficiently broad to cover the machine which he has built that did not come within the scope of the claims of the original patent. Under these conditions, such manufacturer has been held to be immune from the effect of the broad claims of the reissue, under the doctrine of intervening rights since this manufacture was established in view of the narrow scope of the original patent and before the reissue patent was effective. As to such a manufacturer, the broadened claims in the reissue are not operative. This ground of "intervening rights" is one of the reasons why the Patent Office will not ordinarily grant a reissue with broadened claims after two years from the issue of the original patent, because the Patent Office assumes that within two years from date of the original patent, intervening rights have arisen somewhere in the United States. This two year period is purely an arbitrary period, but, nevertheless, it has become entrenched, through practice and decisions so that it is now, in effect, a universal rule. If intervening rights have arisen within the two year period, these rights to be effective as a defense must be proven. After the two year period, they are presumed and the Courts may hold the patentee has lost his rights to a broadened patent because he did not act promptly.

The situation is different where the claims of the original patent are made more narrow by the reissue. Under these conditions, intervening rights could not arise, so, therefore, a narrowed reissue may be obtained at any time during the seventeen year life of the original patent. There are no limitations on the number of reissues which may be granted, that is, a patentee may reissue his patent several times if he likes but under these conditions, it is very doubtful if a second reissue may be granted to broaden the claims beyond those in a preceding reissue. In other words, if a series of reissues are obtained, each succeeding reissue should be more narrow in its claims than the preceding one, except perhaps in very special cases where the several reissues occurred within two years after the grant of the original patent.

A reissue application must be signed by the original inventor or his administrator exactly the same as an original specification. Where any part of a patent has been assigned, it is necessary for the assignee to acquiesce in the reissue before the reissue will be granted. The Patent Office makes a title search after each application for reissue is filed and if no assignment of record is found, then merely the signature of the in-

ventor is all that is necessary, but if an assignment of record is found, then the assignee must acquiesce in the reissue before it will be granted.

Loss of a Patent

A patent is, in effect, a deed and therefore is a valuable document. The same applies to an assignment of a patent. The loss or destruction of such a valuable document might be a serious calamity except for the fact that the law provides that any person making application to the Patent Office and paying a fee required to by law may obtain certified copies of written or printed records or drawings, including copies of Letters Patent, belonging to the Patent Office. These certified copies are authenticated by the seal of the Patent Office and are certified to by the Commissioner or a duly designated representative. The law further provides that all such certified documents shall be evidence in all cases where the originals could be evidence.

It therefore follows that a duly certified copy of an original patent or assignment is of substantially the same force and effect as the original. The grant of a patent is considered as a separate document from the printed drawings, specification, and claims. Therefore, in order to obtain a complete certified copy of a patent, the request for the certificate should include the grant as well as the mere certification of the copy of the patent. When printed copies of patents are sold to the public, a copy of the grant is not included. A copy of the grant, however, is recorded in the Patent Office in special books or libers maintained for this purpose.

Grant of a Patent No Assurance Against Infringement of Some Prior Patent

When the inventor receives his patent, he will find that the grant states:

"Now, therefore, these Letters Patent are to grant unto said *John Doe*, his heirs and assigns for the term of seventeen years from the date of this grant the exclusive right to make, use, and vend the said invention throughout the United States and territories thereof."

The inventor may, and often does, assume that this grant gives him the absolute right to make, sell and use his invention without any danger whatever of being stopped because of infringement of some prior patent. He may reason from the language of this grant that the issuance of a patent to him is, in effect, insurance by the Government of a positive right to proceed to exploit his invention. He may conclude that the Government would not grant him a patent on something that he had no right to commercialize. Such a line of reasoning seems perfectly logical until the true legal effect of a patent of the United States is understood. The word "exclusive" in the grant does not mean an inclusive right. What it does mean is that the grant establishes the right to exclude others from making, using, or selling the patented invention, providing, of course, that the patent is valid. Therefore, when the proper legal effect of the word "exclusive" is understood, it will be seen that while the patentee may be able to prevent others from using his patented invention, he, by the same reasoning, may be excluded from exploiting his own invention because of the rights of some prior patentee whose patent is sufficiently broad to cover the field in which he came with his patented improvement.

In the granting of patents, the Patent Office is not concerned with the claims of prior patents but is concerned only with the novelty of the invention which is disclosed in the later application, and the patent upon such application is granted only for these features that are new in the art. Where an invention is the first of a new art, every subsequent invention in that particular line following the original is of necessity an improvement upon the first invention. Therefore, if the original invention is patented with a patent of sufficient scope to cover the basic invention, then each subsequent patent granted on improvements in this particular line will necessarily be dominated by the basic patent. If the Patent Office were concerned with the question of later devices disclosed in applications infringing earlier patents, there could be no patents granted on improvements on a basic invention until after the basic patent had expired. For example, Bell's patent on the telephone was a basic patent, and if this rule of law was in effect no telephone patents could have been granted until the Bell patent expired. This is not the fact.

The situation where the plaintiff has a broad patent and the defendant has a patent covering his specific advance in the art, has frequently been before the Courts. The Courts have said that the fact the defendant has a patent on the device which he is making shows that at least there are patentable differences between the plaintiff's disclosure and the alleged infringing structure. This difference may afford a ground for argument that defendant's device is not an infringement—not because of any legal right of the defendant because of his patent—but because the existence of defendant's patent is clear evidence of a difference between it and the plaintiff's invention. In an art such as garments, or buttons, or some other highly developed art, the plaintiff's claims may be so limited by the prior art that a proper legal interpretation of the claims so constricts the scope of the plaintiff's claims that the defendant's device is not an infringement due to this established difference. The Courts are inclined to deal more severely with an infringer who copies a patented device than with an infringer who has attempted to produce something of his own creation rather than to merely appropriate the labors of someone else. Therefore, the fact that the defendant has secured a patent on his device is at least evidence that the defendant is not a mere copyist who has deliberately taken the plaintiff's device without having made any efforts to create something of his own.

The value of a United States patent, therefore, resides primarily in the right to exclude others from making, selling or using the patented invention and thereby prevent competition on the specific patented device. It does not in any way insure against infringement of some prior unexpired patent.

The only way for a patentee to be informed on the question of infringement is to study the claims of every unexpired prior patent in the particular art and to construe the language of these prior patents in accordance with a proper interpretation of the claims thereof in view of the art which preceded these patents. This requires an understanding of the art in question and also a

full knowledge of the law of patents. Such a task is a difficult one and is obviously a job for a competent patent lawyer, who may be assisted by an engineer or an expert in the particular art in question in order to accurately formulate the facts upon which he may base an opinion as to the legal aspects of the situation.

A United States Patent Is Effective Only in the United States

The patentee may conclude that having secured his patent, which is a property right, that he is protected in this right throughout the world. This is not the case. A United States patent is enforcible only throughout the United States and territories thereof. It has no force and effect in any foreign country. The same is true as to patents of all countries; they have no extra-territorial extent. The Supreme Court of the United States has held that a United States patent can not be enforced against a ship registered under a foreign flag even when such a ship is in a United States port. The legal reason being that such ship is, in effect, foreign territory and subjects herself to the jurisdiction of United States when in a United States port, for certain limited purposes only, and that patent infringement suits are not included within these limitations.

Where an infringing machine, composition of matter, or article of manufacture is manufactured abroad and is sold or used in the United States, the situation is different. A suit for patent infringement may in this case be brought against the seller, or user, in the United States. Because, as we have pointed out, a United States patent comprises the right to exclude sale or use, as well as manufacture in the United States and territories. It is another story however if the claims of a United States patent covers a process, or a mold, but does not cover the article *per se* produced by the process or the mold. In such case, it will be observed where the process or mold is only used abroad, the United States patent can not reach the manufacturer and the article of manufacture (which may be the thing from which real profit is made) that is shipped into the United States for sale and use, is free from infringement—since there is no patent on it. No redress can be charged because this article is made by a patented process or mold, since the process or mold never gets into the jurisdiction of the United States Courts. The inventor is out of luck. The answer is, either to try to patent the article in the United States or take out foreign patents covering the process or mold.

Where a patented machine is manufactured in United States for sale or use abroad, the patentee may sue an unauthorized manufacturer making the article in the United States. In this case infringement has occurred in the United States because of the making of the machine within the territory covered by the United States Patent.

Personal User Not Immune

There is a mistaken belief by many persons that anyone may make a patented invention for his own personal use without infringing a patent covering the invention. This is not the law. There are no such exceptions as to the rights of a patentee. His patent is just as good against an individual who makes for himself as it is against one who makes for commercial profit. The only difference is that in most cases where an individual has made a patented device for his own use, it would cost the patentee more to stop the individual infringer than it is worth, so therefore the individual may be permitted to get away with his infringement without being molested. Any city, municipality, or state may be sued if officially infringing a patent. The officers who carry out the infringing acts can only be sued in their official capacity, not as private individuals. Even the Government of the United States which grants the patent may be sued for infringement. In this case of a suit against the Government no injunction will issue, but the patentee if successful, will be awarded a reasonable compensation for use of his patented invention.

The Government Does Not Enforce Patents

It is frequently asked that since a patentee has paid fees to the Government to get his patent and that the Government has granted the patent, why does not the Government stand back of the patentee and fight infringers for him? Patents are personal property. There is no sound legal reason why a patent for an invention should receive any more consideration than a patent on land for a homestead. The mere fact that enforcible title comes through the Government has nothing to do with it. The real reason is that both a land grant and a patent on an invention are species of property and that the Government is not directly interested with alleged civil wrongs that relate only to property of the individuals concerned. The Government provides courts for litigants who claim their property rights are being invaded, and patents are in this respect the same as any other private property.

Patents may not, however, legally be used as a basis for some unlawful purpose. For example, patents may not lawfully form the foundation for an illegal combination in restraint of trade. In this case, patents again stand exactly the same as any other property, such as plants, mines, railroads, or other property owned by the alleged illegal combination. This question came before the courts in the case of the so-called "Bathtub Trust," in which were involved certain patents relating to the manufacture of enameled ware. The Court held, in effect, that the fact that patents were the basis of the illegal monopoly was no excuse for an unlawful association, the real purpose of which was unlawful price fixing in restraint of legitimate competition and trade.

The Government Does Not Guarantee Patents

Patentees often ask why the Government does not guarantee the validity of a patent which it has granted? There are several reasons why this can not be done. Patents are granted *ex parte* largely on assertions of the applicant, that he is the first inventor, that the invention has not been in public use, etc. All the Government can do is to supervise the form of the document, and to make a survey of the novelty of the invention submitted by the applicant. The Patent Office has collected an enormous amount of data on all scientific and technical subjects, such as domestic and foreign patents, publications, books, and some old models, all of which are open to the public for study and research. Everything cited by the Examiner is available at all times for public inspection. The survey of novelty by

the Patent Office is based on this public information, and the applicant, or patentee may avail himself of this information at any time. It is up to the applicant or his attorney to draft valid claims in view of all this prior art. Usually no thorough search is made by the applicant. He claims as much or more than he is entitled to claim and then he relies on the Examiner making the search to restrict the claims. The Examiner has but a very short time to search for references and he does the best he can under the circumstances to cite the best references available, but there can be no guarantee that the Examiner's search is completely exhaustive. The Examiner may not find the best prior art, due to faulty classification of reference files, or lack of time to make a thorough search. Furthermore, the Examiner has no practical way of knowing what has been done in remote plants, or what may have been sold or in public use in remote places, or the work of some individual engineer, unless the facts have gotten into public print. Under all these many circumstances, it would be unfair to the public at large if every patent was guaranteed by the Government so that an innocent infringer could not attack the validity of a patent as a defense against a charge of infringement.

The Government does grant patents which are *prima facie* valid. This means the patentee comes into Court with the presumption that he has a valid patent and the burden is heavily upon the defendant to prove the patent is not valid. The proof necessary to invalidate a patent must be very strong. It must go beyond a reasonable doubt. It is the same strength of proof that is required in criminal cases. It has been often said that proof necessary to break a patent must be of the same character and strength as proofs necessary to hang a man.

Therefore, it will be seen that while the Government does not guarantee the validity of patents it does place such force in the sealed document that the patentee is in a very strong position that can only be successfully assailed by one who had marshalled sufficient facts to show that the patent should never have been granted in the first place. This is all that can be expected from the Government and it is as much as public security can justify.

While patents are merely property, people sometimes attach unusual importance to them and feel a special pride in being accorded the honor of being the inventor of a patented device. Some years ago a story was told of the then Commissioner of Patents receiving a communication from a remote section of the country, something like the following:—

> "Please send me a patent C. O. D. I don't care what it is on so long as it is a big patent. I was the most prominent man in our town until John Smith got a patent on a gate and now people think he is smarter than I am and I want to take him down a peg or two by getting a bigger patent than he has."

The American Oil Burner Association reports that space for its tenth annual show and convention, to be held in the Hotel Stevens, Chicago, June 12-16, was approximately half taken in the first 30 days of offering, with five months before the opening.

Tractor-Mounted General Electric Arc Welders

General Electric arc welding apparatus mounted on tractors constructed by the Cleveland Tractor Company is now available for use in remote places where, heretofore, it has been difficult to supply current to the desired point of welding. Prior to the development of the tractor-mounted welder, there has not been available a self-propelled, mobile welding unit. The nearest approach to this sort of equipment was a trailer-mounted, gas engine-driven, steel-wheeled trailer unit which required an additional source of power for movement.

The weight of the arc welder does not materially affect the stability of the tractor, the load being carried directly on the heavy chrome nickel steel shaft which rests in the track frame of the machine. The mounting does not interfere with the drawbar and leaves the tractor free for any drawbar work. The equipment is particularly suitable for oil, gas, and water line construction and repair work, for repair work in construction camps in out-of-the-way places, for structural steel erections, and for maintenance of way work on railroad frogs, switches, and bridges.

The Plibrico Jointless Firebrick Co. of Chicago, Ill., announces that a manufacturing plant has been established at Lake Shore Road and Eighth Street, New Toronto, Ontario, for the manufacture of Plibrico Jointless Firebrick in Canada. The factory will be operated by a new Canadian company to be known as Plibrico Jointless Firebrick, Limited.

Plibrico Jointless Firebrick is already used extensively in the Canadian market. It was introduced in Canada more than 15 years ago and has been used throughout the Dominion.

Mr. E. Morley Wilson of Toronto will be managing director of the new concern.

The Riley Stoker Corporation, Worcester, Mass., announces that all sales of Riley steam generating and fuel burning equipment in the Chicago territory will be handled by Messrs. Hardin, Oswald and Moyer. Mr. C. L. Smith continues his association with this office. The location of the office remains at 1101 Marquette Building, Chicago, Ill.

The Riley Stoker Corporation also announces the establishment of an Indianapolis office. Sales of Riley steam generating and fuel burning equipment in the Indianapolis territory will be handled by B. J. Schneider, 420 Continental Bank Building, Indianapolis, Ind.

The Davis Coal and Coke Company, Baltimore, Md., announces the appointment of E. H. Nicoll as Sales Agent in charge of its Philadelphia office in the Land Title Building. Mr. Nicoll has been a member of the Davis sales organization for the past four years and succeeds N. W. Garrett, who has been assigned to other duties.

Two Modern Boiler Plants in Russia Use Pulverized Fuel Firing

By HANS COERPER
BERLIN, GERMANY

VARIOUS articles have appeared in the technical press about the two new iron and steel centers being erected simultaneously in Magnitogorsk and Kusnezk, Russia. The great size of these projects and their advanced engineering features makes them of particular interest. At Magnitogorsk there eventually will be five steam power plants aggregating 632,000 kw. equivalent capacity. Two of these will serve the blast furnaces of which there will be eight. Two, blast furnaces, the largest in Europe, are now in operation. Three main central electric plants will serve the mining and metallurgical works and the other power and heating requirements of the area.

While the general data of these projects have been given in the published articles referred to, relatively little information has appeared to date concerning the boiler plant equipment. At the time of this writing (December 30, 1932) there were in operation five of the eight boiler units ordered for the blast furnace plants at Magnitogorsk and three of the four boiler units ordered for Kusnezk. The reports received indicate highly satisfactory operation but it should be pointed out that these reports are not based on normal load conditions as the steam requirements thus far have been relatively light.

The units for both Magnitogorsk and Kusnezk are of

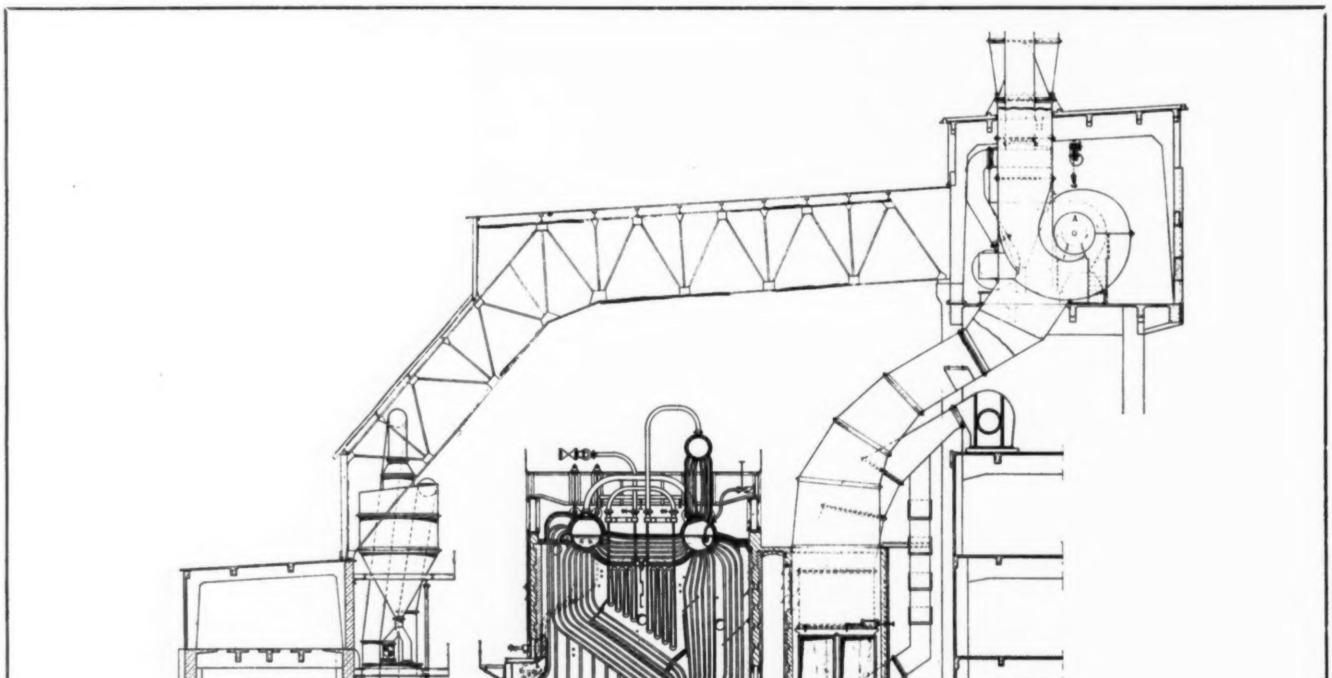


Fig. 1—Cross section of one corner-fired boiler unit and air preheater in Magnitogorsk central power plant. Elevation of coal preparation and handling plant is shown on left.

practically identical design except for a slight difference in the type of bent tube boiler being used.

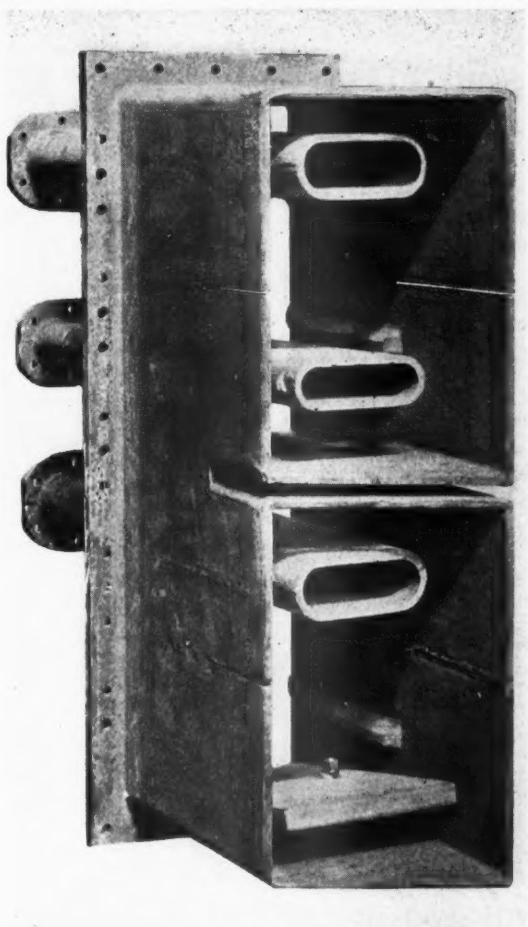


Fig. 2—Combination pulverized coal and gas burner.

The general layout of the furnace boiler and coal preparation plant is shown in Fig. 1. The design data are as follows:

Effective radiation heating surface, sq. ft.	3,870
Boiler heating surface, sq. ft.	18,300
Superheater surface, sq. ft.	11,200
Air heater surface, sq. ft.	76,400
Furnace volume, cu. ft.	19,100
Steam pressure, lb. per sq. in.	440
Steam temperature, deg. fahr.	800
Feedwater temperature, deg. fahr	330
Preheated air temperature, deg. fahr.	700
Maximum continuous load, lb. per hr.	330,000
Combustion rate at maximum load B.t.u. per cu. ft. per hr.	22,500

The coal burned in both plants is Siberian coal from the Kusnezk district. The following is a typical analysis of this coal:

Upper heating value, B.t.u. per lb.	13,600
Lower heating value, B.t.u. per lb.	13,300
Volatile matter, per cent	7.5
Ash, per cent	7.0
Moisture, per cent	3.0

At first thought it would seem uneconomical to ship coal by railroad cars from Kusnezk to Magnitogorsk (a distance of over 1500 miles) but since the cars are loaded on their return with iron ore from Magnitogorsk the transport costs are cut down considerably.

Various tests which were made with Kusnezk coal in Germany before ordering the furnaces showed that the coal had better burning characteristics than similar European low volatile coal. It was possible to burn the coal in a completely water-cooled furnace of the Lopulco type (Lopulco Steam Generator at Hardenberg built by Kohlenscheidungs-Gesellschaft m.b.H., Berlin) with corner-firing without any difficulty. Consequently the Russian engineers decided to equip both the Magnitogorsk and Kusnezk plants with Lopulco furnaces.

The furnace walls are built of plain bare tubes which are fed by a separate feed drum. The feed drum receives its water from the lower boiler drum. Aside from the downcomer tubes to the feed drum there are no other outside riser or downcomer connections.

The coal is fed by six Lopulco Type R duplex feeders to twelve burners located in the four corners of the furnace. Two feeders always supply one row of four burners located in one elevation. There are three rows of coal burners.

The furnaces were guaranteed to burn efficiently not only coal but also blast furnace gas, coke oven gas and fuel oil or any combination of these fuels with coal. The gas and oil burners are located between or above the coal burners. Fig. 2 shows the construction of the coal and coke oven gas burners.

Prime Movers Committee Report on Boilers, Superheaters and Economizers and Boiler Water Level Problems

The Prime Movers Committee, National Engineering Section, has recently issued a report, N. E. L. A. Publication No. 241, covering boilers, superheaters and economizers and boiler water level problems.

This bulletin contains reports of operating companies and equipment manufacturers on their experiences during the past year in fusion welding, high pressure boilers, boiler drums and tubes, moisture removal, gage glasses, boiler baffles, soot blowers, slagging, air infiltration, continuous blow down, feedwater regulators, non-return valves, pressure drop, economizers and superheaters.

Relatively few boiler installations have been made during the past year. As a result, companies have had time to pay more than usual attention to overcoming operating problems, changing equipment to improve performance, and reducing maintenance. Many interesting statements describing how this has been accomplished are reported in this bulletin, together with opinions in regard to the reliability and performance of boiler accessories.

Copies of this report can be obtained from the National Electric Light Association, 420 Lexington Avenue, New York, N. Y. Prices: 90 cents to members; $1.40 to non-members.

EMPLOYMENT SERVICE

This page is contributed by COMBUSTION for the benefit of unemployed engineers who are qualified to assume responsibility for the design, construction or operation of steam power plants.

There are many plants today which could save thousands of dollars annually by taking advantage of the opportunity which present conditions afford to secure the services of highly trained and experienced men at moderate salaries. Some of the engineers listed on this page have been employed by the largest engineering firms in the country in important positions and at salaries commensurate with their abilities. As soon as business conditions improve the services of these men will be in demand and will not be available at any such salaries as they are now willing to accept.

COMBUSTION hopes it will have the privilege of bringing these engineers into contact with those who can profitably employ them.

A-30. *Education:* Electrical Engineering, Michigan Agricultural College. *Experience:* From 1925 to the present superintendent of power for a large automobile company. Engaged successively by a stoker manufacturing company, a large chemical company and a consulting engineering firm. Has had considerable experience in stoker design, manufacture and installation and in the maintenance and operation of large power plants. Has had extensive experience in the organization and administration of steam plant personnel.

A-31. *Education:* Mechanical Engineering, 1921, Lehigh University. *Experience:* Recently chief engineer of a coke quenching equipment company, and previously as manager of the industrial furnace department of a large engineering organization. Has had extensive experience with the design, manufacture and installation of industrial furnaces and coke quenching equipment. Has also served for two years as manager of the experimental department of a power plant equipment manufacturer. Intimately familiar with coals, coke and other fuels, their characteristics and their best fields of application.

A-32. *Education:* Home study courses in steam engineering. *Experience:* Service engineer for the past six years for a western boiler company. Has had broad experience in feedwater treatment, fuel burning equipment, etc. Was previously employed as chief engineer of an industrial organization. Has also had considerable experience in power plant piping, steam and hot water heating of buildings. Applicant especially qualified for power plant operation and service work.

A-33. *Education:* Electrical Engineering, Ohio State University and evening courses at the University of Akron. *Experience:* Recently employed as assistant efficiency engineer by a large middle-west public utility company. Experience included tests on boilers, turbo-generators and auxiliaries, cost control studies and instrument maintenance. Previously test engineer for large steel company. Work comprised calibration, installation and maintenance of many makes of pyrometers, flow meters, etc.

A-34. *Education:* Mechanical Engineering, 1917, Cornell University. *Experience:* Has been identified with several of the prominent stoker companies for the past ten years. Work included sales organization and promotion and servicing. Has also designed and supervised manufacture and installation of stokers. Intimately acquainted with coals, their characteristics and their applicability, having been employed by a large coal company until recently.

A-35. *Education:* Mechanical Engineering at Stevens Institute, Combustion course at Hays School of Combustion—Modern Business course at Alexander Hamilton Institute. *Experience:* Assistant superintendent of power for a large eastern oil company having plant consisting of over 100 boilers ranging from 200 to 1400 hp. Three years as chief engineer of a large paper company. Five years as fuel engineer of one of largest coal companies. In this last capacity developed considerable sales ability required by position.

A-36. *Education:* B. S. in Mechanical Engineering at Purdue University, 1914. *Experience:* Last three years, assistant chief engineer for a large pipe line company, where he did special work in design, operating economy on steam and diesel power plants. Previously for four years, chief engineer in charge of operation, maintenance, design and manufacture of new equipment for company engaged in production of sand, gravel and shell.

A-37. *Education:* St. Anthony's College, Santa Barbara, and home study course. *Experience:* 1925 to 1932 chief operating engineer of a 30,000 kw. turbo-generator plant for large copper mining company. Was in charge of construction and operation of a waste-heat plant and three 1000 hp. motor-driven blowing engines. Had much experience with high pressure steam boilers. Previously engineer for a large Pacific Coast utility company. Has had extensive experience in supervision of construction of steam-electric equipment.

A-38. *Education:* B. S. in Mechanical Engineering, University of Berkeley, 1930. *Experience:* For last three years—ship power plant operator—licensed second assistant marine steam engineer. Previously, for five years in charge of care and maintenance of large apartment buildings. This man is particularly qualified for drafting, clerical work in engineering company, or as a power plant operator.

A-39. *Education:* B.S. and M.S. in Mechanical Engineering, University of California. *Experience:* Seven years with public utility companies in appraisal, special reports, analysis of designs, electrical and mechanical, on electric distribution systems, substations and generating plants. Three years designing central heating plants and underground electrical and steam heat distribution systems. Also considerable work on electrical and mechanical equipment for buildings, including refrigeration and air conditioning. Two years graduate research work at University of California on thermodynamics and heat insulation. Extensive experience in cost analysis and valuation of substations and hydro and steam electric plants.

A-40. *Education:* Case School of Applied Science, B.S. *Experience:* 5 years as superintendent and construction engineer for western power company. 4 years in charge of power plant engineering for a large consulting engineering firm. 9 years as sales engineer, the last seven of which have been spent with one of the largest manufacturers of boiler and combustion equipment. Well qualified for a position as sales engineer or for responsible position in connection with the design or operation of power plants.

Note: Space limitations make it impossible to present adequately the detailed experience and qualifications of the above applicants. The fact that many of them have had similar experience will make it difficult for those interested in their services to make a selection. Consequently, COMBUSTION will be glad to assist inquirers from the detailed information in its files by making recommendations as to applicants who are best qualified for particular positions, or will give the inquirer more detailed information concerning particular applicants. Where inquiry is made concerning certain applicants, as identified by number, such applicants will be asked to communicate directly with the inquirer unless otherwise requested. All inquiries should be addressed to COMBUSTION, Attention of Editor, 200 Madison Avenue, New York.

NEW CATALOGS AND BULLETINS

Any of the following publications will be sent to you upon request. Address your request direct to the manufacturer and mention COMBUSTION Magazine

Corrosion of Piping

A reprint of an article entitled "Combating Corrosion of Piping" has been issued by Cochrane Corporation, 17th Street below Allegheny Avenue, Philadelphia, Pa. The paper among other sub-topics, explains particularly the highly significant factor known as "hydrogen ion concentration," water supplies, and methods of eliminating oxygen from solution. 12 pages, 8½ x 11.

Draft Regulator

A new publication has been issued describing the Carrick Furnace Draft Regulator. This bulletin includes a discussion of the importance of proper draft regulation and sets forth the manner in which the Carrick Draft Regulator effects proper draft control. The construction of this device is described and the positive operation is shown diagrammatically. 12 pages, 8½ x 11—Carrick Engineering Company, Michigan City, Indiana.

Flue and Duct Expansion Joints

A pamphlet has been issued entitled "Bergen Point Iron Works Expansion Joint Solves Expansion Joint Problems." The joint is claimed to allow contraction and expansion of the flue without rupture or distortion of the metal. Bergen Point Iron Works, Bayonne, N. J.

Industrial Steam Trap

Bulletin 1231 describes the design and construction of Nicholson Industrial Steam Traps. These traps are suitable for application to large unit heaters, large pipe coils, high pressure drips, blast coils, dry kilns, all kinds of dryers, large jacketed kettles, etc. 4 pages, 8½ x 11—W. H. Nicholson & Company, 12 Oregon Street, Wilkes-Barre, Pa.

Instruments

Catalog 40 entitled Moeller Instruments, lists and describes a very extensive line of thermometers, hydrometers, barometers, draft gages, hygrometers, vacuum gages, recording barometers, etc. Many illustrations, tables of data and price lists are included. 88 pages and cover, 8½ x 11—Moeller Instrument Company, 261 Sumpter Street, Brooklyn, New York.

Power Plant Piping

A very comprehensive catalog has been issued describing power plant piping. This catalog discusses the desirable features of good piping and sets forth the ways in which National piping meets the standards. The physical properties are described and piping subjected to several types of destruction tests are shown. Specific applications of National pipe in power plants are described and illustrated, steam tables, flow of steam tables, an entropy diagram and other useful tables and charts are appended. 40 pages. 8½ x 11—National Tube Company, Pittsburgh, Pa.

Roller Chain Drives

Bulletin 51 entitled "Morse Roller Chain Drives" comprehensively describes the design and construction features of the various types of chains manufactured. It contains the following topics "How to Design Roller Chain Drives," "How to Figure Chain Length," "Lubrication," etc. Many tables give data relative to size, prices and other statistical information. 56 pages and cover, 8½ x 11—Morse Chain Company, Ithaca, N. Y.

Rotary Oil Burners

Type D-R Rotary Oil Burners for Heating Boilers, High Pressure Steam Boilers and All Other Furnaces is the title of bulletin 70, issued by the National Airoil Burner Company. The design and construction features of this burner are described and illustrated. Specifications are included. Bulletin 71 gives the installation instructions for the burners. Bulletin 70, 4 pages, 8½ x 11—Bulletin 71, 8 pages, 8½ x 11—National Airoil Company, 1327 Girard Avenue, Philadelphia, Pa.

Rubber Goods

A new catalog has been issued entitled "Buyer's Guide to Mechanical Rubber Goods." It contains illustrations and data on many of the most widely used mechanical rubber products. Some sections of this catalog are entitled: "Facts about Rubber Belts," "Directions for Ordering," Facts about Hose," and "Loss in Pounds Pressure per 100 Feet of Hose." All rubber tubing, rubber packing, chute linings, pump valves, rubber matting, rubber cements, etc., are described. 24 pages and cover, 8½ x 11—Diamond Rubber Company, Inc., Akron, Ohio.

Steam Turbines

Form No. 1950 entitled "Six Ways to Reduce Power Costs" outlines and illustrates six applications of different types of turbines for specific power and steam requirements. A diagrammatic hook-up of the turbine unit is also shown. A list of typical users of the six types of turbo-generator units is appended. 6 pages, 8½ x 11—Moore Steam Turbine Corporation, Wellsville, New York.

Sump Pump

Bulletin D-450-52A describes and illustrates the design and construction features of the Worthington Axiflo Sump Pump. A sectional view is included with brief descriptions linked directly by arrow to the parts described. Data and tables. 4 pages, 8½ x 11—Worthington Pump and Machinery Corporation, 2 Park Avenue, New York, N. Y.

Transmission Belting

A new eight page supplement to its mechanical goods catalog on its "Highflex Transmission Belt" has just been issued by The B. F. Goodrich Rubber Company, Akron, Ohio. The supplement discusses function and varied operating conditions of transmission belting, some of the complexities involved in making rubber belts, discussion of rubber compounds and construction used in Highflex and flexibility.

Turbines for Mechanical Drive

A new pamphlet recently issued describes the General Electric turbines for mechanical drive. These turbines have been designed especially to drive pumps, fans, compressors, pulverizers and similar apparatus. They can simultaneously supply low-pressure steam for process or seasonal heating or other purposes. Two and three stage, 90 to 500 hp. 4 pages, 8½ x 11—General Electric Company, Schenectady, New York.

Vibrating Screen

Bulletin No. 1362 describes the Link-Belt Vibrating screen. This screen is available in two general types: the "NP" Unbalanced Pulley Type and the "PD" Heavy Duty Positive Drive Type. The "NP" screen is claimed to be especially effective in the screening of small coal and coke. This bulletin sets forth in detail the features of construction. 8 pages, 6 x 9—Link-Belt Company, 910 So. Michigan Avenue, Chicago, Illinois.

NOTICE

Manufacturers are requested to send copies of their new catalogs and bulletins for review on this page. Address copies of your new literature

COMBUSTION

to

200 Madison Ave., New York

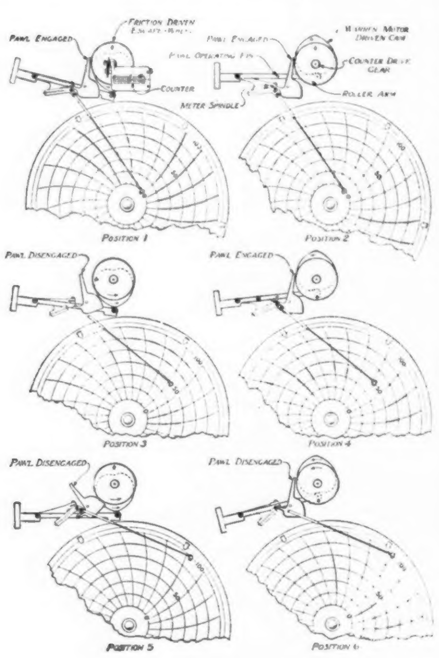
NEW EQUIPMENT

of interest to steam plant Engineers

Escapement Type Integrator

An outstanding development incorporated in the new line of Bailey Fluid Meters recently announced, is the escapement type integrator, which operates in a simple, but accurate manner. The total flow in gallons, pounds or other units, is given on a six-figure counter.

The principle of operation is diagrammatically set forth in the illustration. A



heart-shaped cam, which has a uniform angular rise, is geared to a Warren Synchronous Motor and rotated at the rate of two revolutions per minute. By means of a friction clutch between the cam and the escape wheel, the motor also drives the escape wheel and integrator counter at constant speed when the pawl is not engaged. When the pawl engages with the escape wheel, the integrator counter is held stationary, but the friction clutch allows the cam to continue rotation.

The roller arm is pivoted near its left end to the flow mechanism, so that the position of the pivot varies only with changes in the rate of flow. The right end of the roller arm moves up and down under the action of the rotating cam, causing the pawl operating pin to move up and down also. It is this operating pin which is responsible for engagement and disengagement of the pawl with the escape wheel.

Referring to the illustration, Positions 1 and 2 show the flow recorder at zero rate of flow. In Position 1, the cam and roller are at maximum throw, while in Position 2, they are at the point of minimum throw. In both of these zero rate of flow positions, which represent extreme cam positions, the integrator counter is stationary because the path of the pawl operating pin does not come sufficiently low to disengage the pawl.

Positions 3 and 4 also show the cam and roller in their extreme positions, but the flow recorder is now at 50 per cent of maximum capacity. The increase in rate of flow has resulted in lowering the left end of the roller arm, thus lowering the path travelled by the operating pin. Consequently, during 180 deg. rotation of the cam, the pawl remains engaged with the escape wheel, but during the remaining 180 deg. rotation, it is kept disengaged by the pin. Under these conditions, the integrator runs 50 per cent of the time, which is correct when the rate of flow is at 50 per cent of maximum.

Positions 5 and 6 show the cam and roller in similar positions, but with the rate of flow increased to 100 per cent. Under these conditions, the pawl operating pin keeps the pawl disengaged during 360 deg. rotation of the cam, and consequently the integrator runs continuously.

It is claimed that this escapement type integrator has proved to be very accurate since its operation is governed by the rate of flow at each engagement and disengagement of the pawl. Since the pawl engages and disengages during each revolution of the cam for all rates of flow between 0 and 100 per cent, the integrator total is adjusted to the prevailing rate of flow four times each minute, instead of only once per minute as is customary in the ordinary type of periodic integrator.

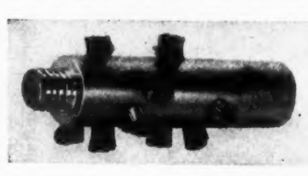
Tube Cleaning Device

Tubrush is a new type of tube cleaner announced by the Vroom Rotary Packing Company, 755 South St., Waltham, Mass. It does its work by cutting and not by scraping as in the usual type. All Tubrushes are accurately sized for the particular tubes to be cleaned and thus the danger of damaging the tube is eliminated.

It may be used with all standard turbines or flexible shaft equipment and is equally well adapted to easy and efficient hand operation.

Mechanically, it comprises a substantial body with continuous, unbent, unstitched, self centering bristles.

For ordinary tube cleaning such as condensers, express boilers, fire tube and water tube boilers, etc. Tubrushes are made in standard sizes and designs. They provide a combination of body sizes and bristles sizes that insure proper flexibility for ease of operation and durability. These Tubrushes are furnished in a wide range of sizes varying by thousandths of an inch to fit all standard tubes. They may also be specially made undersize to allow for excessive scale or other deposit, or oversize for increased inside diameter due to corrosion, wear or other conditions. For special work the bristles can be made as rigid or as flexible as the work requires.

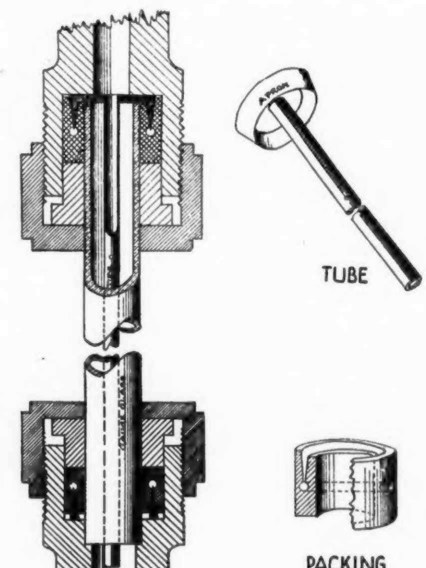


For certain non-ferrous, plated or tinned tubes special Tubrushes are made with spring tempered phosphor bronze bristles. Also with bodies of bronzed aluminum, monel metal, stainless steel, etc. All Tubrushes have threads on each end so that they can be easily reversed, thus equalizing wear on bristles and assisting in making them self-sharpening.

New Water Column Gage-Glass Packing Device

After several years of research and experimentation, Frank A. Rumatz, 1514 Plass Avenue, Tokepa, Kansas, has developed a new water column gage-glass packing device which will materially lengthen the operating life of gage-glass and reduce breakage to a minimum.

The research work done in this development disclosed two prominent contributing causes of gage-glass breakage, namely, first, the upper end of the glass projecting beyond the packing devitrified quickly; and second, the periodic blowing down of the water column with the attendant impingement of steam, eroded the glass internally, weakening it considerably. In order to over-



come these two objectionable factors a novel packing combination was conceived consisting of an integral nozzle, wedge, and packing as illustrated.

The purpose of the nozzle is to prevent steam impingement. It is apparent that since the nozzle extends beyond the bottom of the glass the steam will not come in contact with the glass. The purpose of the apron and special packing is to hermetically seal the upper end of the glass and thereby prevent erosion. The apron wedge also permits a more uniform compression and a greater packing contact area with the walls of the stuffing box and the glass. High rubber packing will be used for

pressures up to 250 lb. per sq. in. and asbestos and rubber for higher pressures.

The new device has been tested under various pressures and all operating conditions and it is claimed that results indicated that the operating life of gage-glass will be very materially increased, and, in many cases, the gage-glass will last indefinitely unless broken by other causes.

This device is applicable to all stationary, locomotive and marine boilers. The installation and operation of this new type of water column gage-glass is similar to the ordinary gage-glasses now in general usage. For further details apply to Frank A. Rumatz at the above mentioned address.

Device for Detecting Magnetic Impurities

Magnetic impurities in asbestos, mica, glass, sands, and other similar materials are easily detected and their extent measured by means of a new magnetic device announced by the General Electric Company. The equipment was first developed for use in the General Electric shops for determining the amount of magnetic oxide of iron present in asbestos, but the manufacturer expects it to have wider application in industry.

In its application to analyzing asbestos the device tests specimens containing up to 5 per cent of magnetic ferric oxide impurities.

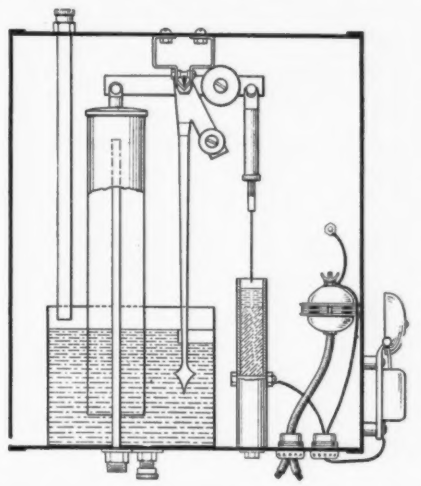
Both free iron and black ferric oxide (Fe_3O_4) are conducting and magnetic, and if present in asbestos are detrimental to its insulating qualities. The more common oxides of iron—ferrous oxide (FeO) and ferric oxide (Fe_2O_3)—are, on the other hand, non-magnetic and non-conducting. If a chemical analysis is made of a sample asbestos, all of the iron and its oxides are determinable only as total iron present—no differentiation may be made between the injurious and the non-injurious types. The new analyzer, on the other hand, reports only the magnetic content.

The device consists of a differential permeameter and an indicating device. In the case of asbestos, the magnetic effect of the iron impurities is proportional to the quantity of impurities present. The permeameter consists essentially of a coil for producing a high magnetic field for magnetizing the specimen, and two equal secondary coils for measuring the magnetic effect. These latter coils are placed in the magnetizing coil and connected to the indicator with their induced voltage in opposition. The specimen is placed in one of the secondary coils, thus disturbing their electrical equality. The effect on the indicator is proportional to the quantity of magnetic impurities present.

The indicator has two scales calibrated in terms of the percentage of impurities in a 10-gram specimen. The range of the first is up to 1 per cent, and of the second up to 5 per cent. Changing from one scale to the other is accomplished by means of a switch.

Draft Gage Alarm

A sensitive electric alarm system for Ellison pointer draft gages has been developed by the Ellison Draft Gage Company, 214 W. Kinzie Street, Chicago. It can be furnished in either the Ellison straight-line or the dial type pointer draft gages for minus, plus or differential readings, and for either high or low draft alarm. Transformer can be furnished for either 220 or 110 volts,



dry cells being used for other than a.c. current.

The system consists of a transformer, a bell, and a mercury chamber and contact rod comprising the switch. The chamber is composed of hard fiber which is partly filled with mercury. The mercury is covered with oil for sealing the electric arc and also for sealing the mercury against oxidation. The electric contact rod is suspended on the beam of the gage, on a knife edge bearing, and is adjustable so as to ring the bell at any point of the scale, within a variation not to exceed .01 in.

The illustration shows the dial type gage equipped with alarm for low minus draft.

Tubular Oil Heater

The Coen Company of Los Angeles and New York has developed and placed on the market a new 8-pass tubular outside joint oil heater. This new outside joint construction is claimed makes it impossible for a leaky tube joint to permit oil to enter the steam space and find its way into the boiler, hot well or cooling tower. The tube sheets are rolled steel, two tube sheets at each end, with a space between them open to the air. Thus any old or steam leak will drain to the atmosphere. The shell also has an expansion joint built into it to relieve it of expansion strains. The heater shell is covered with insulating material protected by sheet iron and secured by chromium plated bands.

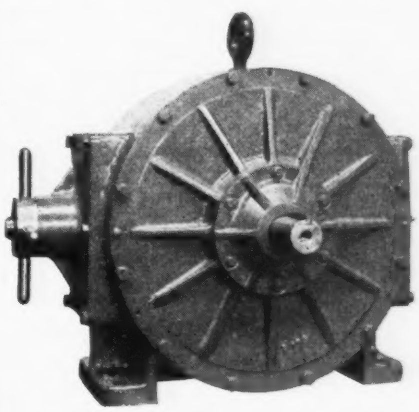
In operation, steam is admitted to a cored annular passage at either end of shell. From this passage it is distributed into the heater shell through a row of holes on the inner circumference. There is a steam connection at either end of the heater and drain connections at four points, two at each end. The heater may be used as a cooler by reversing the oil flow through the heater and circulating cold water through the steam space. Hot oil may be rapidly cooled in this manner from any temperature. Coen outside joint oil heaters are adaptable to either vertical or horizontal installations, and may be connected in any multiple combination.

The Coen outside joint heater is built for all capacity requirements, and for all practical working pressures and temperatures.

Hydraulic Pumps and Motors

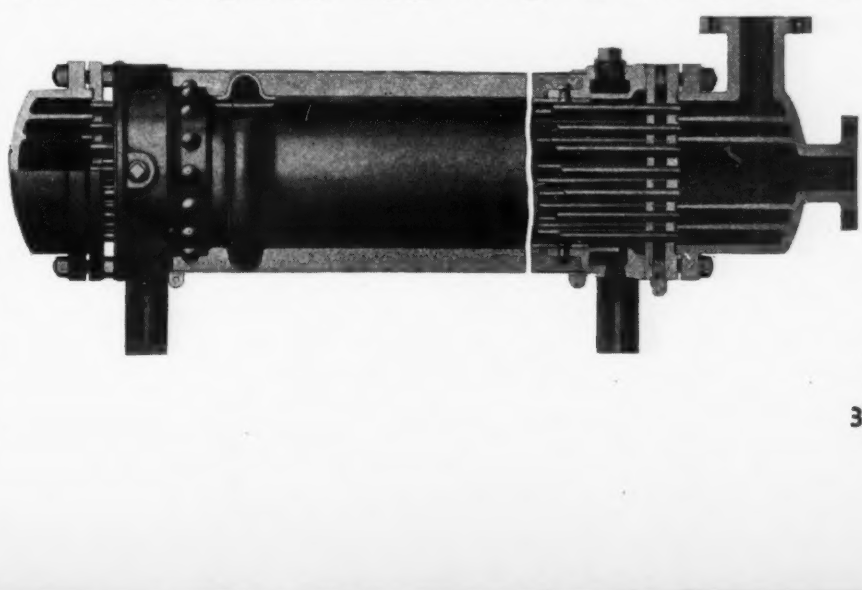
A complete new line of hydraulic pumps and motors of the rotary radial piston type has been developed and placed on the market by the Northern Pump Company, Minneapolis, Minn.

These pumps are available in capacities ranging from 1 g.p.m. to 200 g.p.m. and for pressures as high as 4000 lb. per sq. in. pumping oil for hydraulic systems. The volume of discharge can



be changed to deliver any amount from 0 to the maximum capacity of the pump, and the discharge can be reversed without stopping the pump or changing the speed or rotation. These pumps are available with a complete line of automatic controls and semi-automatic valve mechanisms. They are fitted throughout with nitralloy which is claimed will permanently resist wear which might result from dirty oil. All pumps incorporate a balanced pressure design whereby hydraulic forces are balanced to prevent heavy bearing loads at high pressures.

These pumps are suitable for high pressure lubrication, stoker drives, ash discharge rolls and many other uses.



REVIEW OF NEW TECHNICAL BOOKS

Any of the books reviewed on this page may be secured from In-Ce-Co Publishing Corporation, 200 Madison Avenue, New York

Power Plant Engineering and Design

By Frederick T. Morse

PROFESSOR MORSE of the Louisiana Polytechnic Institute in the Preface to *Power Plant Engineering and Design* explains the purpose of his book as follows:

"This book is an attempt to present in one volume a thorough study of electric generating stations, including public service, industrial and institutional plants. In so doing, there has been no attempt to treat other than American practice. While the book is designed for use as a college text, it is hoped that the information it contains and the method of presenting that information, will render it of value to the practicing engineer.

"The task of designing, constructing, and operating a power plant requires an understanding of both the mechanical and the electrical features of the plant. Furthermore, a book of this character should place due emphasis upon the economic factors underlying power plant design and construction. Hence, the writer has not attempted to divorce the mechanical and electrical features of the power plant, and has directed attention towards economy in power production."

The following partial list of chapter headings and subdivisions clearly indicates the scope of this book: General Introduction (Power and Industry, Scope of Power Plant Engineering, Power and the Standard of Living); The Variable Load Problem (Industrial Production and Power Generation Compared, Ideal and Realized Load Curves, Methods of Meeting Load Variability); Power Plant Economics; The Power Plant Building (Preliminary Layouts, Typical Power Plant Structures, The Stack, Power Plant Roofs, Foundations, Cranes, Cleaning); Diesel Engine Power (Growth of Diesel Engine Power, Field for Diesel Engine Power); The Hydro-Electric Plant; Vapor Cycles and Their Heat Balances (Vapor Cycles, Rankine Cycle, Regenerative Cycle, The Reheating Cycle); Steam Boilers, Prime Movers and Condensers (Trend of Central Station Practice, Trend of Industrial Plant Practice, High Pressures, High Temperatures, Boiler Types, Boiler Efficiency, Water Walls); The Combustion Loop (Fuels, Combustion, Smoke, Fuel Storage and Reclamation, Conveying Systems, Grates and Stokers, Furnace Design, Ash Handling); The Feed Water Loop (Necessity for Boiler Feed Water Treatment, Remedial Measures); The Piping System (Piping Classification, Fittings and Valves); Electric System Equipment; Electric System Layout; Conclusion (Purpose of Meters in the Power Plant; Classification of Meters, Selection of Instruments, Records and Their Use).

There are more than 400 figures and 70 tables in this book. It contains 813 pages, including a comprehensive index, size 6¼ x 9¼. Price $6.50.

Symposium on Steel Castings

THE presentation and publication of the ten extnsive technical papers comprising the Symposium on Steel Castings have been sponsored jointly by the American Foundrymen's Association and the American Society for Testing Materials, the chief purpose being to provide the engineering profession with authoritative information on the properties of steel castings. Carbon-steel and alloy-steel castings are covered.

The first two papers give, respectively, a general survey of the industry and statistical data on steel casting production in the United States. Then follows a contribution on the design of steel castings, which emphasizes the importance of cooperation between designer and founder, and discusses extensively contraction and crystallization phenomena under such headings as crystal formation, feeding of sections, effect of heat transmission, deep pockets, linear shrinkage, etc.

A paper entitled "Purchase Requirements for Steel Castings with Notes on Physical Properties in Test Bars and in Commercial Castings" follows. This explains design factors influencing test specimen results, chemical limitations for carbon steel, and summarizes the A. S. T. M. and other specifications for carbon-steel and alloy-steel castings. One of the most extensive papers gives physical and mechanical properties of some well-known cast steels.

Another paper thoroughly reviews the representative properties of pearlitic carbon, low-alloy steels, containing various percentages of molybdenum, vanadium, chromium and nickel, chromium steels for high temperatures, and pearlitic manganese steels.

A technical paper on "Castings of Corrosion-Resistant Steels'" gives extensive data on the principal classes of these alloys, covering physical properties at room and elevated temperatures, machining and welding behavior, coefficient of thermal expansion, melting point, maximum temperature for safe use, etc.

Other papers cover austenitic manganese steel castings, problems and practices in the heat treatment of steel castings, and fusion welding as related to steel castings.

Extensive oral and written discussion adds to the value of the papers, presenting a broader view of the subjects. Diagrams, charts and tables have been extensively used by the authors to enable a quick and clear presentation of the data.

This book contains 254 pages, size 6 x 9. It is bound in a heavy paper cover. Price $1.00.

BOOKS

1—Economics for Engineers

By E. L. Bowers and R. H. Rowntree

490 Pages 6 x 9 Price $4.00

A practical presentation of economic principles and problems for engineers and engineering students. The treatment is as concise as possible and emphasizes the engineering aspects of economic theory and business activity. The discussion of costs and pricing is especially thorough. Some aspects of business activity, such as marketing, investments and insurance, not ordinarily included in texts on economics, are treated here for the convenience of the engineering audience to whom the book is addressed.

2—Combustion in the Power Plant (A Coal Burner's Manual)

By T. A. Marsh

255 pages Price $2.00

The author's discussion of coals and combustion is simple and understandable. His consideration of equipment —stokers, boilers, furnaces, fans and auxiliaries—is thoroughly practical. He tells how to select a stoker for the best available coal; how to design furnaces and arches; how to analyze draft problems and design chimneys, gas flues and boiler passes; how to purchase coal and calculate steam costs. He gives to every phase of his subject a practical interpretation that makes this book of exceptional value to men actually identified with steam plant design and operation.

3—Water Analysis For Sanitary and Technical Purposes

By Herbert B. Stocks

135 Pages Price $3.50

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Books Nos. ....

Boiler, Stoker and Pulverized Fuel Equipment Sales

As reported by equipment manufacturers to the Department of Commerce, Bureau of the Census.

Boiler Sales

Orders for 213 boilers were placed in December by 72 manufacturers

	Number	Square feet
December, 1932	213	154,866
December, 1931	390	371,240
January to December (inclusive, 1932)	3,580	3,377,567
Equivalent period, 1931	7,508	6,327,262

NEW ORDERS, BY KIND, PLACED IN DECEMBER, 1931-1932

Kind	December, 1931		December, 1932	
	Number	Square feet	Number	Square feet
Stationary:				
Water tube	37	189,453	16	77,988
Horizontal return tubular	22	24,054	15	14,995
Vertical fire tube	40	13,214	31	4,637
Locomotive, not railway	7	4,808	1	251
Steel heating	269	127,285	120	38,719
Oil country	...	......	...	......
Self contained portable	14	11,989	26	17,605
Miscellaneous	1	437	4	671
Total	390	371,240	213	154,866

Mechanical Stoker Sales

Orders for 98 stokers totaling 24,375 hp. were placed in December by 55 manufacturers

	Installed under			
	Fire-tube boilers		Water-tube boilers	
	No.	Horsepower	No.	Horsepower
December, 1932	78	11,774	20	6,601
December, 1931	117	17,034	22	7,519
January to December (inclusive, 1932)	920	122,346	367	139,173
Equivalent period, 1931	1,889	252,571	574	187,507

Pulverized Fuel Equipment Sales

No orders for pulverizers reported in December

	Pulverizers				Water-tube Boilers		
	Total Number	No. for new boilers, furnaces and kilns	No. for existing boilers	Total capacity lb. coal per hour for contract	Number	Total sq. ft. steam generating surface	Total lb. steam per hour equivalent
STORAGE SYSTEM							
December, 1932	..	..	..	......	..	......	....
December, 1931	..	..	..	......	..	......	....
January to December (inclusive, 1932)	..	..	..	....	..	......	....
Equivalent period, 1931	8	7	1	250,000	4	126,471	1,797,000
DIRECT FIRED OR UNIT SYSTEM							
December, 1932	..	..	..	......	..	......	....
December, 1931	2	1	1	2,500	2	7,850	22,000
January to December (inclusive, 1932)	73	48	25	392,388	64	463,194	3,536,260
Equivalent period, 1931	72	52	20	450,960	58	417,327	4,455,595
					Fire-tube Boilers		
December, 1932	..	..	..	......	..	......	....
December, 1931	1	..	1	500	1	1,500	7,000
January to December (inclusive, 1932)	13	2	11	13,300	13	20,310	114,650
Equivalent period, 1931	35	11	24	39,300	37	59,761	347,100

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